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A Key to Some Southern California Fishes Based on Vertebral Characters

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CHARLES R. CLOTHIER
May, 1950

A KEY TO SOME SOUTHERN CALIFORNIA FISHES BASED ON VERTEBRAL CHARACTERS

By
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INTRODUCTION

The identification of larval forms of marine fishes, of fish fragments found in stomach contents and of fossil fish is often difficult. As an aid to such work a study is being made of the vertebral characteristics of adult marine fishes found off the coasts of Mexico, California, Oregon and Washington and a key based on these characteristics is being constructed.

The possibility of such a key was suggested by Ford (1937), who described at considerable length and with the aid of some excellent photographs the differences in the vertebral columns of several teleostean fishes, approaching the subject from the "functional" angle without any attempt to form a key.

Work was begun on the present study in 1938 and has been continued as material and time were available. Because of the large number of species involved it has been found necessary to divide the study into geographical units. The first unit, covered in this paper, comprises 163 species of fish, omitting the Elasmobranchii, found between Point Conception and San Diego. Work will be continued on fishes from the areas to the north and south of this region and published as completed.

The material for this study consisted mainly of fresh adult specimens which were lightly boiled to loosen the flesh from the bones. To secure less common forms it became necessary to use material which had been preserved in alcohol or formaldehyde. Since no amount of boiling will loosen the flesh from the bones of preserved specimens, the clearing and staining technique described by Hollister (1934) was adopted with some modifications (see appendix). This technique was also used on the smaller fresh individuals to avoid loss of vertebrae in the boiling process.

In naming the various parts of the skeleton, Starks (1901) was followed, with one exception. Starks calls the last fanlike tail segment articulated with the last true vertebral centrum, the "hypural." Since the term "hypural" is used by many authors to designate the spines which are loosely attached to this fanlike plate and the word "urostyle" is used for the plate itself, this latter terminology was adopted. The basis for separating the abdominal and caudal vertebrae is that of Hubbs and Lagler (1947).

In the fin ray counts, the last two rays were counted separately, unless they originated from the same base, in which case they were counted as one ray. Following usual procedure the spine counts are given

in Roman numerals and the soft ray counts in Arabic. A comma separates the spine number from the ray number in the same fin. In the case of two dorsal fins, a hyphen separates the individual counts of the two separate fins. Finlets are given in Roman numerals following, and separated from, the ray counts by a hyphen.

It is recognized that fin counts probably will not be of much use in identification of stomach contents, so every effort was made to key the fish without resort to fin counts. In a number of cases when it was impossible to do this the fin counts have been included in the key. They are also given in the descriptive text as corroborative data. Other sources have been consulted to obtain additional fin ray counts. The numbers here given include the greatest known range for each species.

The form and shape of the vertebrae may undergo changes and modifications between the young and the adult forms which may create some confusion where the key is based on adults only. Such a variation has already been described for *Clevelandia ios* and related forms (Clothier, 1946). Furthermore, examination of additional specimens may indicate that other skeletal features change with growth and, consequently, certain characters here used may later prove of doubtful diagnostic value.

USE OF THE KEY

The key is built upon several characteristics. The first is the total number of vertebrae including the urostyle. The second is the number of the vertebra upon which the first haemal spine occurs and the third the number of the vertebra upon which the first haemal arch occurs. In the more complex parts of the key it is necessary to take other characters into account, such as the size and shape of the supraoccipital crest and other bones of the skull, the length of the first (or in some cases the second) haemal spine, the size and shape of the neural spines, etc. Some of these characters are very difficult to describe in other than general terms, i.e., "a large bulge in the prootic region" and the author recognizes that this is a point of weakness in the key.

Use of the key will be facilitated by familiarity with the following points:

FIRST HAEMEL SPINE

In *Thunnus*, *Neothunnus*, *Sarda* and *Oncorhynchus* the first haemal spine is indeterminate because it is only a minute process and succeeding spines become gradually longer. The vertebra on which these short haemal spines suddenly increase in length and curve backward was selected as the diagnostic character for these species and is entered in the key as "sudden increase in length."

In *Halichoeres semicinctus* and *Oxyjulis californica*, on the vertebra where the first haemal spine occurs, the haemapophyses join to form a small haemal arch and then extend outward and downward before again joining and forming a large secondary arch and a short haemal spine.

In *Pimelometopon pulchrum*, there are on the vertebra carrying the first haemal spine, two arches, one above the other. The haemal arch is normal in size and is formed by a weak bridge of bone connecting the two haemapophyses. The secondary arch, which is much the larger, is

formed by a heavy bone extending from both haemapophyses and meeting at the base of the haemal spine. The haemapophyses project beyond the bridging of this second arch as two large conspicuous spines. (See page 63.)

In *Etrumeus orthonops*, *Sardinops caerulea* and *Alosa sapidissima* the bone forming the bridge of the haemal arches gradually thickens dorso-ventrally, at the same time drawing together the extensions of the haemapophyses until the first haemal spine is formed. The first haemal spine occurs at the point where this structure changes from a bifurcate to a single point.

In *Albula vulpes* the first haemal spine is indeterminate because the haemal processes fuse at the base only and remain bifurcate throughout.

In *Oligocottus snyderi* the parapophyses on the vertebra just preceding the first haemal spine are the same length as the spine and are very apt to be confused with it. This is especially true because all the other parapophyses preceding this very long pair are short.

THE HAEMEL FUNNEL

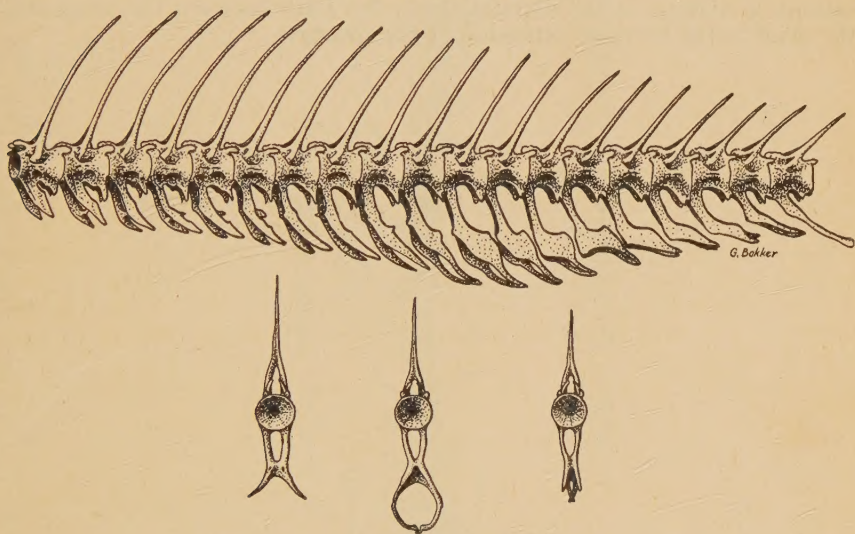


FIGURE 1. *Atherinopsis californiensis* showing the haemal funnel

In *Atherinops*, *Atherinopsis* and *Leuresthes*, the position of the first haemal spine is obscured by what has here been termed the haemal funnel. This structure begins 6 to 10 vertebrae in front of the first haemal spine. (Figure 1.) It is formed by a sudden increase in the length of the haemapophyses beyond the bridging of the haemal arch to almost form another arch, but the ends of the haemapophyses do not fuse together to close this second arch. The haemapophyses gradually come closer together, thus narrowing the funnel, and the vertebra on which they meet and fuse becomes the vertebra of the first haemal spine.

FIRST TWO VERTEBRAE

In the genus *Syngnathus* the first two vertebrae can be seen from the ventral side only as they are completely covered by bony modifications of the parapophyses laterally, and by the neural processes dorsally, so that they look like a continuation of the skull.

SMALL ATLAS

In *Cetengraulis mysticetus* the atlas is very small and hard to find and is apt to be missed entirely if care is not taken in making the count.

UROSTYLE

In the genus *Porichthys* the upper lobe of the urostyle is jointed (Figure 21). However, it is to be counted as one and not two vertebrae.

LENGTH OF VERTEBRAL COLUMN

In a number of cases reference is made to the number of times a structure will go into the vertebral column. The length of the vertebral column is defined as the distance from the joint between the atlas and the skull to the farthest extension of the urostyle.

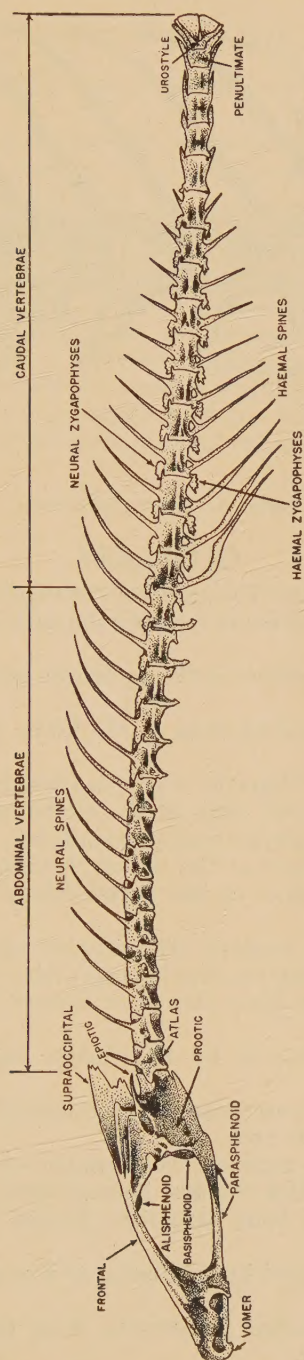


FIGURE 2. Parts of a fish skeleton. Drawing of a *Pneumatophorus diego* skeleton

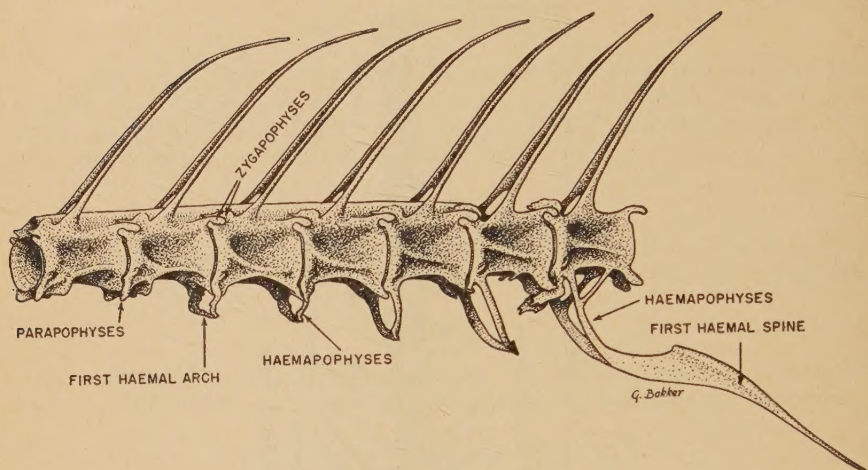


FIGURE 3. Parts of a fish skeleton

GLOSSARY

Abdominal Vertebrae. The anterior vertebrae without haemal spines.

Alisphenoids. Paired bones forming the anterior portion of the brain case.

Atlas. The first vertebra in the vertebral column articulated to the skull.

Basisphenoid. A median bone at the lower anterior portion of the brain case.

Caudal Vertebrae. Posterior vertebrae bearing haemal spines.

Centrum. The central part of the vertebra excluding all spines, parapophyses, haemapophyses and zygapophyses.

Epiotics. Paired bones at the upper posterior part of the cranium.

Frontals. Paired bones on the dorsal side of the cranium, anterior to the brain case.

HA followed by a number. The number of the vertebra, starting with the atlas, upon which the first haemal arch occurs.

Haemal Arch. The bony structure formed by the joining of the haemapophyses.

Haemal Spine. Formed by the fusion and prolongation of the haemapophyses.

Haemapophyses. Vento-lateral projections from the centrum which unite to form the haemal arch.

HS followed by a number. The number of the vertebra, starting with the atlas, upon which the first haemal spine occurs.

Neural Arch. The bony structure formed by the joining of the neurapophyses.

Neural Spine. Formed by the fusion and prolongation of the neurapophyses.

Neurapophyses. Dorsal projections from the centrum which join to form the neural arch.

Parapophyses. The bony projections on each side of the anterior ends of the centruns in the abdominal region to which the ribs are attached.

Parasphenoid. The median bone forming the ventral boundary of the skull.

Penultimate. The last true vertebra to which is articulated the urostyle.

Prootics. Paired bones on the ventro-lateral sides of the cranium.

Supraoccipital. A median bone at the upper posterior angle of the cranium, usually bearing a crest.

Urostyle. The fanlike tail segment articulated with the last true vertebra.

Vomer. A median bone forming the anterior part of the roof of the mouth and joining with the anterior end of the parasphenoid.

Zygapophyses. The small bony projections from the centra which interlock with each other to give rigidity to the vertebral column. Those projecting anteriorly are prezygapophyses; posteriorly, postzygapophyses. Those on the upper part of the centrum are neural zygapophyses, and on the lower part, haemal zygapophyses.

VERTEBRAL KEY

VERTEBRAE 18

- HS 6; HA 6. *Verrunculus polylepis*, page 79.
 HS 10; HA 10. *Mola mola*, page 79.

VERTEBRAE 23

HS 10-14.

HA 8-11.

- a. Haemal and neural spines on last 4 vertebrae lying flat, parallel to vertebral column. *Trachurus symmetricus*, page 51.
- aa. Haemal and neural spines on last 4 vertebrae not parallel to vertebral column. *Cynoscion parvipinnis*, page 57.

VERTEBRAE 24

HS 10.

HA 7. *Scorpaena guttata*, page 65.

HA 8-10. *Trachurus symmetricus*, page 51.

HS 11.

HA 6.

- a. Second interhaemal spine enlarged and hollowed out anteriorly. First haemal spine bends back close to 2nd. *Eucinostomus argenteus*, page 49.
- aa. Second interhaemal spine not enlarged or hollowed out anteriorly. All haemal and neural spines spaced about equidistantly. *Polydactylus approximans*, page 49.

HA 7-10.

- a. Supraoccipital crest high.
 - b. Supraoccipital crest thin. No bony ridge on anterior edge. Haemal spines not thickened antero-posteriorly. First haemal spine 5-11 in vertebral column.
 - c. First haemal spine 5-6 in vertebral column and extending straight down from centrum and curving slightly forward. *Chloroscombrus orqueta*, page 51.
 - cc. First haemal spine 7-11 in vertebral column and bent back close to 2nd.
 - d. First haemal spine 10-11 in vertebral column. Basisphenoid very large, extending forward and upward nearly to midline of orbital opening.
 - e. Neural and haemal zygapophyses enlarged and husky. *Umbrina roncadore*, page 57.
 - ee. Neural and haemal zygapophyses smaller. *Cheilotrema saturnum*, page 55.
 - dd. First haemal spine 7 in vertebral column. Basisphenoid very small, not extended into orbital opening. *Eucinostomus argenteus*, page 49.
 - bb. Supraoccipital crest with a heavy bony ridge on anterior edge. First 4-5 haemal spines greatly thickened antero-posteriorly. First haemal spine long and straight; $2\frac{1}{2}$ in vertebral column. *Chaetodipterus zonatus*, page 65.
 - aa. Supraoccipital crest low.
 - b. The haemal and neural spines on the last 4 vertebrae lying flat, parallel to vertebral column. *Trachurus symmetricus*, page 51.
 - bb. Haemal and neural spines on last 4 vertebrae not parallel to vertebral column.
 - c. Third dorsal spine longer than 4th. *Paralabrax nebulifer*, *Paralabrax maculato-fasciatus*, page 47.
 - cc. Third dorsal spine about as long as 4th. *Paralabrax clathratus*, page 47.

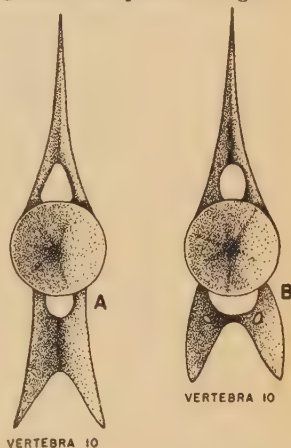
HS 12; HA 9-10. *Mugil cephalus*, page 49.

HS 14; HA 14. *Sphyraena argentea*, page 49.

VERTEBRAE 25

HS 10-11; HA 7-10.

- a. Supraoccipital crest extends to junction of atlas and 2nd vertebra.
- b. Skull concave on top. Supraoccipital crest extends the full length of skull. *Naucrates ductor*, page 51.
- bb. Skull convex on top. Supraoccipital crest originates over posterior edge of orbital opening.
- c. Anterior edge of supraoccipital crest at a 15-30° angle. *Cheilotrema saturnum*, page 55.
- cc. Anterior edge of supraoccipital crest at a 5° angle or less.
- d. Vertebra 10 as in fig. 4A. *Roncador stearnsii*, page 55.
- dd. Vertebra 10 as in fig. 4B. *Umbrina roncador*, page 57.
- aa. Supraoccipital crest not extending past junction of skull and atlas.
- b. First haemal spine 5-6 in vertebral column. *Medialuna californiensis*, page 65.
- bb. First haemal spine 8-9 in vertebral column. *Trachurus symmetricus*, page 51.
- bbb. First haemal spine 12-14 in vertebral column.
- c. Large bulge in prootic region. *Seriphys politus*, page 57.
- cc. No bulge in prootic region. *Menticirrhus undulatus*, page 57.

FIGURE 4. End views of vertebra 10 of, A, *Roncador stearnsii* and, B, *Umbrina roncador*

HS 12; HA 8-10.

- a. First haemal spine directed back towards 2nd, the tip practically touching the 2nd haemal spine. First two neural spines widened until they are in contact with each other. *Seriola dorsalis*, page 51.
- aa. First haemal spine far separated from 2nd. First two neural spines separated from each other. *Trachurus symmetricus*, page 51.

HS 13-14; HA 9-12. *Cynoscion nobilis*, page 57.

VERTEBRAE 26

HS 10 (See page 6); HA 6-7. *Halichoeres semicinctus*, page 63.

HS 11 (See page 6).

HA 5-7. *Oxyjulis californica*, page 63.

HA 8-9.

- a. Preneural zygapophyses on abdominal vertebrae expanded into thin fanlike plates. Supraoccipital crest rudimentary, almost wanting. First haemal spine with a large hole. *Oxyjulis californica*, page 63.
- aa. Preneural zygapophyses, supraoccipital crest and 1st haemal spine not as above.
- b. Supraoccipital crest thin and moderate in height, the posterior margin not extending beyond junction of skull and atlas. Basisphenoid small, not extending upward into orbital opening. *Xenistius californiensis*, page 55.
- bb. Supraoccipital crest rises to a high point over atlas. Basisphenoid extends onto parasphenoid and projects up into orbital opening. *Anisotremus davidsonii*, page 55.

HS 12 (See page 6).

HA 5-9.

- a. Preneural zygapophyses on abdominal vertebrae expanded into thin fanlike plates. Supraoccipital crest rudimentary, almost wanting. First haemal spine with a large hole. *Oxyjulis californica*, page 63.
- aa. Preneural zygapophyses, supraoccipital crest and 1st haemal spine not as above.
- b. Supraoccipital crest originating over middle of skull. Large bulge in prootic region. *Genyonemus lineatus*, page 57.
- bb. Supraoccipital crest originating on posterior end of skull. Very slight bulge in prootic region. *Sebastes* sp., page 67.

VERTEBRAE 26—Continued

HS 12—Continued

HA 10.

- a. Vertebra 11 with 2 haemal arches, 1 greatly enlarged. (See fig. 5). *Coryphopterus nicholsii*, page 73.
- aa. Vertebra 11 with 1 haemal arch. (See fig. 5).
 - b. Supraoccipital crest originating on posterior end of skull, its posterior edge sloping forward. *Sebastodes* sp., page 67.
 - bb. Supraoccipital crest originating rather abruptly over middle of orbital opening, its posterior edge nearly vertical. *Chromis punctipinnis*, page 63.

HA 11-12.

- a. Greatly enlarged 1st haemal arch occurs on same vertebra as 1st haemal spine. First 3 haemal spines each recessed into and partly engulfed by spine behind. *Hypsypops rubicunda*, page 63.
- aa. First haemal arch 1-2 vertebrae in front of 1st haemal spine and not enlarged. Haemal spines well separated. *Chromis punctipinnis*, page 63.

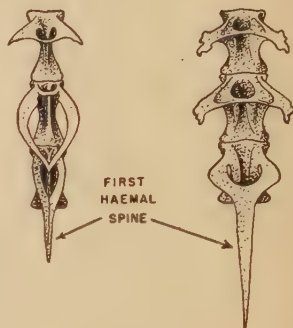


FIGURE 5. Ventral views of *Coryphopterus nicholsii* (left) and *Chromis punctipinnis* (right) showing the difference in the haemal arch just preceding the first haemal spine

HS 13.

HA 7-8. *Genyonemus lineatus*, page 57.

HA 9. *Stereolepis gigas*, page 47.

VERTEBRAE 27

HS 11-12 (See page 6).

HA 5-11.

- a. Supraoccipital crest rudimentary, almost wanting. Preneural zygapophyses on abdominal vertebrae expanded into thin fanlike plates. First haemal spine with a large hole. *Oxyjulis californica*, page 63.
- aa. Supraoccipital crest short, originating behind orbit. Preneural zygapophyses not expanded into thin fanlike plates. No large hole in 1st haemal spine. *Sebastodes* sp., page 67.
- aaa. Supraoccipital crest longer, originating over the middle of the orbit. Preneural zygapophyses not expanded into thin fanlike plates. No large hole in 1st haemal spine. *Girella nigricans*, page 65.

HA 12. *Remora remora*, page 51.

HS 13; HA 11-13.

- a. Top of skull concave. Spines of 1st dorsal fin modified into a sucking disc. *Remora remora*, page 51.
- aa. Top of skull not as above. Spines of 1st dorsal fin not as above. *Caulolatilus princeps*, page 59.

VERTEBRAE 28

HS 12; HA 9-11. *Pimelometopon pulchrum*, page 63.

HS 14; HA 14. *Infratridens rhessodon*, page 75.

VERTEBRAE 29

HS 13; HA 8-9. *Palometa simillima*, page 51.

HS 14; HA 14. *Infratridens rhessodon*, page 75.

VERTEBRAE 30

HS 13; HA 8-9. *Palometa simillima*, page 51.

HS 14-16; HA 10-14.

- a. First haemal arch 3-5 vertebrae in front of 1st haemal spine. *Pneumatophorus diego*, page 53.
- aa. First haemal arch on same vertebra as 1st haemal spine. *Infratridens rhessodon*, page 75.

VERTEBRAE 31

HS 11-12; HA 9-10. *Clinocottus analis*, page 71.

HS 13.

HA 8-10.

a. Second haemal spine 10-11 in vertebral column. *Clinocottus analis*, page 71.

aa. Second haemal spine 4 in vertebral column. *Palometa simillima*, page 51.

HA 13. *Micrometrus minimus*, page 61.

HS 14.

HA 10-12. *Pneumatophorus diego*, page 53.

HA 14.

a. Atlas $1\frac{1}{4}$ - $1\frac{1}{2}$ times longer than 2nd vertebra. Large parapophyses on atlas, none on 2nd vertebra. *Cyclothone acclinidens*, page 37.

aa. Atlas normal in size with no parapophyses.

b. Supraoccipital crest very heavy, posterior edge not extending over atlas. *Coryphaena hippurus*, page 53.

bb. Supraoccipital crest lighter, posterior edge extending over atlas. *Micrometrus minimus*, page 61.

HS 15.

HA 10-12. *Pneumatophorus diego*, page 53.

HA 13-15.

a. Atlas $1\frac{1}{4}$ - $1\frac{1}{2}$ times longer than 2nd vertebra. Large parapophyses on atlas, none on 2nd vertebra. *Cyclothone acclinidens*, page 37.

aa. Atlas normal in size with no parapophyses.

b. Supraoccipital crest high, sharp pointed. *Micrometrus minimus*, page 61.

bb. Supraoccipital crest reduced to a very small posterior extension. *Gillichthys mirabilis*, page 73.

HS 16.

HA 10-12.

a. Base of each haemal spine occupying nearly the whole length of centrum, and perforated with a large hole. Haemal zygapophyses very small. *Gasterosteus aculeatus*, page 72.

aa. Base of each haemal spine perforated with smaller hole. Haemal zygapophyses expanded into large saw-toothed plates. *Pneumatophorus diego*, page 53.

HA 13-16.

a. Supraoccipital crest high, sharp pointed. *Micrometrus minimus*, page 61.

aa. Supraoccipital crest reduced to a very small posterior extension.

b. Base of each haemal spine perforated with a large hole. *Gasterosteus aculeatus*, page 72.

bb. No holes at bases of haemal spines. *Gillichthys mirabilis*, page 73.

HS 17-19; HA 17-19. *Typhlogobius californiensis*, page 73.

VERTEBRAE 32

HS 11; HA 9-10. *Clinocottus analis*, page 71.

HS 12-13.

HA 8-10.

a. Front of skull gently inclined. (See fig. 6). *Artedius lateralis*, page 71.

aa. Front of skull steeply inclined. (See fig. 7. See fig. 8 for differences between *C. analis* and *C. recalvus*.) *Clinocottus analis*, *Clinocottus recalvus*, *Oligocottus rubellio*, page 71.

HA 12-13. *Micrometrus minimus*, page 61. *Brachyistius frenatus*, page 59.

HS 14-16.

HA 8-9. *Oligocottus rubellio*, page 71.

HA 10-12.

a. Base of each haemal spine occupying nearly the whole length of centrum, and perforated with a large hole. Haemal zygapophyses very small. *Gasterosteus aculeatus*, page 72.

aa. Base of each haemal spine perforated with a smaller hole. Haemal zygapophyses expanded into large saw-toothed plates. *Pneumatophorus diego*, page 53.



FIGURE 6. Skull of *Artedius lateralis*



FIGURE 7. Skull of *Clinocottus analis*

VERTEBRAE 32—Continued

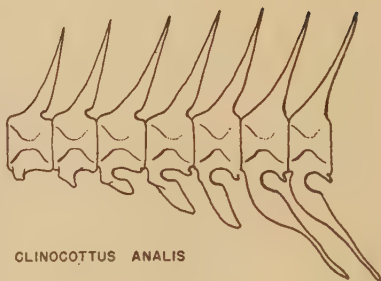
HS 14-16—Continued

HA 10-12—Continued

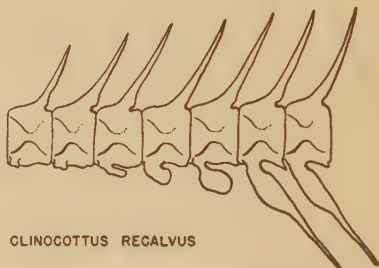
- aaa. No holes at bases of haemal spines.
Ilypnus gilberti, page 73.

HA 13-16.

- a. Atlas $1\frac{1}{4}$ - $1\frac{1}{2}$ times longer than 2nd vertebra. Large parapophyses on atlas, none on 2nd vertebra. *Cyclothone acclinidens*, page 37.
- aa. Atlas normal in size with no parapophyses.
- b. Parapophyses on 3rd vertebra project sideways a distance of about the length of 1 centrum and then gradually shorten on the next 4 vertebrae, reaching a length of about $\frac{1}{2}$ centrum. *Ilypnus gilberti*, page 73.
- bb. Parapophyses on 3rd and following vertebrae about equal in length.
- c. Supraoccipital crest reduced to a very small posterior extension.
- d. Base of each haemal spine perforated with a large hole. *Gasterosteus aculeatus*, page 72.
- dd. No holes at the bases of the haemal spines. *Gillichthys mirabilis*, page 73.
- cc. Supraoccipital crest high, sharp pointed. *Micrometrus minimus*, page 61. *Brachyistius frenatus*, page 59.



CLINOCOTTUS ANALIS



CLINOCOTTUS RECALVUS

FIGURE 8. Showing differences between *Clinocottus analis* and *Clinocottus recalvus*

- HS 17-19; HA 17-19. *Typhlogobius californiensis*, page 73.

VERTEBRAE 33

HS 10-11.

HA 8-10.

- a. Second haemal spine 19-21 in vertebral column. *Icelinus quadriseriatus*, page 69.
- aa. Second haemal spine 10-11 in vertebral column. *Clinocottus analis*, page 71.

HS 12-13.

HA 8.

- a. Second haemal spine 19-21 in vertebral column. *Icelinus quadriseriatus*, page 69.
- aa. Second haemal spine 10-11 in vertebral column. *Oligocottus rubellio*, page 71.

HA 9-11.

- a. Front of skull gently inclined. (See fig. 6). *Artedius lateralis*, page 71.
- aa. Front of skull steeply inclined. (See fig. 7).
- b. Second haemal spine 10-15 in vertebral column. (See fig. 8 for differences between *C. analis* and *C. recalvus*). *Clinocottus analis*, *Clinocottus recalvus*, *Clinocottus globiceps*, *Oligocottus rubellio*, *Oligocottus maculosus*, page 71.
- bb. Second haemal spine 19-21 in vertebral column. *Icelinus quadriseriatus*, page 69.

- HA 12-13. *Micrometrus minimus*, page 61. *Brachyistius frenatus*, page 59.

HS 14.

HA 8-9. *Oligocottus rubellio*, page 71.

HA 12-14.

- a. Supraoccipital crest very low, short and rounded.
- b. One spine each in 2nd dorsal and anal fins. *Quietula y-cauda*, page 73.
- bb. Second dorsal and anal fins without spines. *Ilypnus gilberti*, page 73.
- aa. Supraoccipital crest high and sharp pointed. *Micrometrus minimus*, page 61. *Brachyistius frenatus*, page 59.

VERTEBRAE 33—Continued

HS 15-17.

HA 12-14.

- a. Parapophyses on 3rd vertebra project sideways a distance of about the length of 1 centrum and then gradually shorten on the next 4 vertebrae, reaching a length of about $\frac{1}{2}$ centrum.
- b. One spine each in 2nd dorsal and anal fins. *Quietula y-cauda*, page 73.
- bb. Second dorsal and anal fins without spines. *Ilypnus gilberti*, page 73.
- aa. Parapophyses on 3rd and following vertebrae equal in length. *Gillichthys mirabilis*, page 73.

HA 15-16.

- a. Parapophyses extremely produced, 4-6 times length of 1 centrum, originating high on the midline of the centrum and extending outward and curving slightly downward. *Rimicola eigenmanni*, page 75.
- aa. Parapophyses not as above.
- b. Supraoccipital crest reduced to a very small posterior extension. *Gillichthys mirabilis*, page 73.
- bb. Supraoccipital crest high, sharp pointed.
- c. First haemal spine 4 in vertebral column. First neural spine $5-6\frac{1}{2}$ in vertebral column. *Embiotoca jacksoni*, page 61.
- cc. First haemal spine 5 in vertebral column. First neural spine $8\frac{1}{2}$ in vertebral column. *Zalembeus rosaceus*, page 59.
- ccc. First haemal spine $5\frac{1}{2}$ in vertebral column. First neural spine $6\frac{3}{4}-7\frac{1}{4}$ in vertebral column. *Micrometrus minimus*, page 61.

VERTEBRAE 34

HS 10.

HA 6-7. *Paralichthys californicus*, page 41.HA 8-9. *Icelinus quadriseriatus*, page 69.

HS 11.

HA 6-7. *Paralichthys californicus*, page 41.

HA 8.

- a. Second haemal spine 9-10 in vertebral column. *Oligocottus snyderi*, page 71.
- aa. Second haemal spine 19-21 in vertebral column. *Icelinus quadriseriatus*, page 69.
- HA 9-10.
- a. Second haemal spine 9-11 in vertebral column. *Clinocottus analis*, *Oligocottus snyderi*, page 71.
- aa. Second haemal spine 19-21 in vertebral column. *Icelinus quadriseriatus*, page 69.

HS 12.

HA 8-11.

- a. Second haemal spine 9-15 in vertebral column. *Clinocottus analis*, *Oligocottus snyderi*, *Oligocottus rubellio*, *Oligocottus maculosus*, page 71.
- aa. Second haemal spine 19-21 in vertebral column. *Icelinus quadriseriatus*, page 69.

HA 12.

- a. Anal fin with spines. Dorsal fins joined. *Brachyistius frenatus*, page 59.
- aa. Anal fin without spines. Dorsal fins well separated. *Oligocottus snyderi*, page 71.

HS 13; HA 8-13.

- a. Anal fin with spines. Dorsal fins joined. *Micrometrus minimus*, page 61. *Brachyistius frenatus*, page 59.
- aa. Anal fin without spines. Dorsal fins well separated. *Clinocottus analis*, *Oligocottus snyderi*, *Oligocottus rubellio*, *Oligocottus maculosus*, *Artedius notospilotus*, page 71.

VERTEBRAE 34—Continued

HS 14.

HA 8-9. *Oligocottus rubellio*, page 71.

HA 12-14.

- a. Supraoccipital crest very low, short and rounded.
 - b. One spine each in 2nd dorsal and anal fins. *Quietula y-cauda*, page 73.
- bb. Second dorsal and anal fins without spines. *Ilypnus gilberti*, page 73.
- aa. Supraoccipital crest high, sharp pointed.
 - b. Atlas closely joined to skull. Two large downward projecting knobs on prootic. *Damalichthys vacca*, page 61.
 - bb. Joint between atlas and skull readily distinguished. Two downward projecting knobs on prootic much less prominent.
 - c. First haemal spine as long as second. Orbit large, greatest vertical diameter $2\frac{1}{4}$ - $2\frac{1}{2}$ in length of skull (from vomer to atlas). *Hyperprosopon argenteum*, page 59.
 - cc. First haemal spine shorter than 2nd. Orbit normal size, greatest vertical diameter 3 or more in length of skull (from vomer to atlas). *Micrometrus minimus*, page 61. *Brachyistius frenatus*, page 59.

HS 15-17.

HA 12-14.

- a. Supraoccipital crest very low, short and rounded.
 - b. One spine each in 2nd dorsal and anal fins. *Quietula y-cauda*, page 73.
 - bb. Second dorsal and anal fins without spines. *Ilypnus gilberti*, page 73.
- aa. Supraoccipital crest high and sharp pointed.
 - b. First haemal spine $4-4\frac{1}{2}$ in vertebral column. *Damalichthys vacca*, page 61.
 - bb. First haemal spine 5-6 in vertebral column. *Cymatogaster aggregata*, page 59.

HA 15-17.

- a. Parapophyses extremely produced, 4-6 times length of 1 centrum, originating high on the midline of the centrum and extending outward and curving slightly downward. *Rimicola eigenmanni*, page 75.
- aa. Parapophyses not as above.
 - b. First haemal spine 5-6 in vertebral column. *Micrometrus minimus*, page 61. *Cymatogaster aggregata*, *Zalembius rosaceus*, page 59.
 - bb. First haemal spine $4-4\frac{1}{2}$ in vertebral column.
 - c. Tonguelike projection on anterior edge of basisphenoid. *Embiotoca jacksoni*, page 61.
 - cc. No tonguelike projection on anterior edge of basisphenoid.
 - d. Atlas closely joined to skull. Two large downward projecting knobs on prootic. *Damalichthys vacca*, page 61.
 - dd. Joint between atlas and skull readily distinguished. Two downward projecting knobs on prootic much less prominent. *Hyperprosopon argenteum*, page 59.

VERTEBRAE 35

HS 10.

HA 6-7. *Paralichthys californicus*, page 41.HA 8-9. *Icelinus quadriseriatus*, page 69.

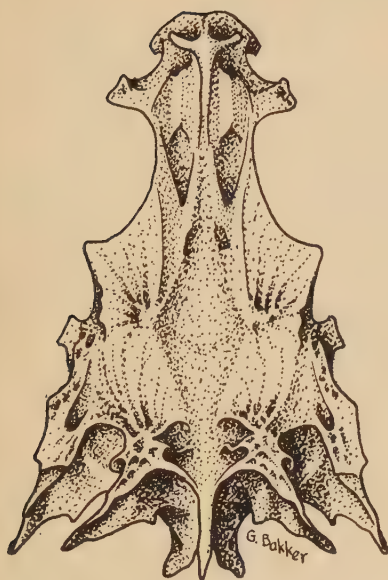
HS 11.

HA 6-7. *Paralichthys californicus*, page 41.

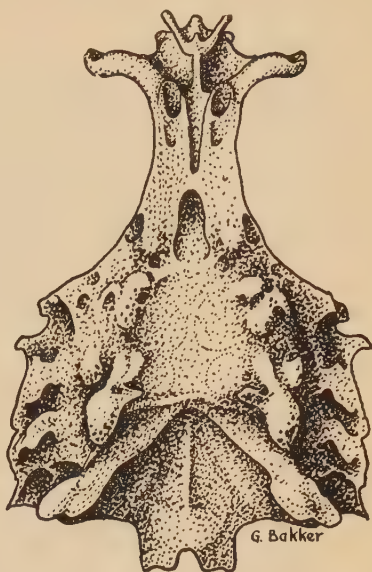
HA 8-10.

- a. Second haemal spine 14-21 in vertebral column.
 - b. Second haemal spine 14-19 in vertebral column. First dorsal spine much longer than 2nd or 3rd. *Chitonotus pugetensis*, page 69.
- bb. Second haemal spine 19-21 in vertebral column. First dorsal spine no longer than 2nd or 3rd. *Icelinus quadriseriatus*, page 69.
- aa. Second haemal spine 9-11 in vertebral column. *Clinocottus analis*, *Oligocottus snyderi*, page 71.

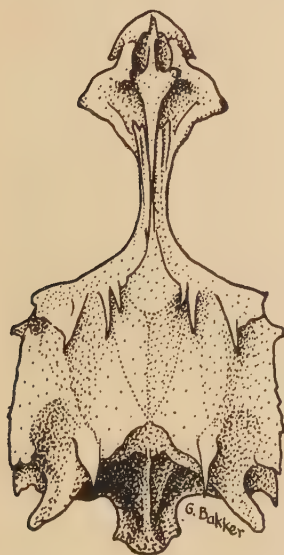
HA 11. *Oligocottus snyderi*, page 71.



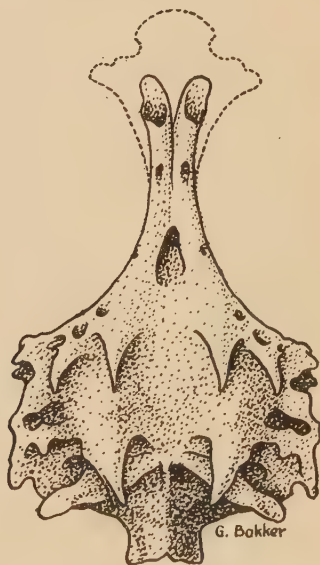
LEPTOCOTTUS ARMATUS



ICELINUS FILAMENTOSUS



CHITONOTUS PUGETENSIS



ICELINUS CAVIFRONS

FIGURE 9. Dorsal views of the skulls of four species of cottoids

VERTEBRAE 35—Continued

HS 12.

HA 8-10 (See fig. 9).

- a. Upper preopercular spine with 3 or 4 barbs hooked upward and forward. *Leptocottus armatus*, page 71.
- aa. No such barbed spine.
 - b. First 2 spines of dorsal fin long and filamentous, much longer than 3rd. *Icelinus filamentosus*, page 69.
 - bb. First dorsal spine much longer than 2nd or 3rd. *Chitonotus pugetensis*, page 69.
 - bbb. First dorsal spine no longer than 2nd or 3rd.
 - c. Second haemal spine 19-21 in vertebral column. *Icelinus quadriseriatus*, page 69.
 - cc. Second haemal spine 9-15 in vertebral column. *Clinocottus analis*, *Oligocottus snyderi*, *Oligocottus rubellio*, *Icelinus cavifrons*, page 71.

HA 11. *Oligocottus snyderi*, page 71.

HA 12.

- a. Anal fin with spines. Dorsal fins joined. *Brachyistius frenatus*, page 59.
- aa. Anal fin without spines. Dorsal fins well separated. *Oligocottus snyderi*, page 71.

HS 13.

HA 8-10. *Clinocottus analis*, *Oligocottus snyderi*, *Oligocottus rubellio*, page 71.

HA 11-13.

- a. Second haemal spine 9-11 in vertebral column. *Oligocottus snyderi*, page 71.
- aa. Second haemal spine 4-6 in vertebral column.
 - b. Supraoccipital crest high, sharp pointed. *Brachyistius frenatus*, page 59. *Micrometrus minimus*, page 61.
 - bb. Supraoccipital crest very small, almost wanting.
 - c. Parapophyses preceding 1st haemal spine short, stubby. (See fig. 10.) *Pleuronichthys ritleri*, page 45.
 - cc. Parapophyses preceding 1st haemal spine long, pointed. (See fig. 11.) *Hypsopsetta guttulata*, page 43.

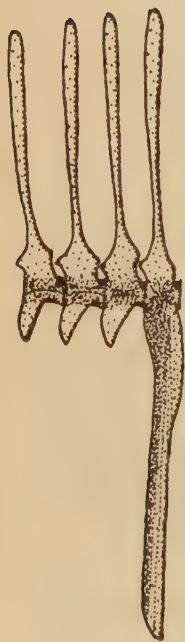


FIGURE 10. (Left) The first haemal spine, and the three vertebrae preceding it, of *Pleuronichthys ritleri*. Drawing made from a cleared and stained specimen



FIGURE 11. (Right) The first haemal spine, and the three vertebrae preceding it, of *Hypsopsetta guttulata*. Drawing made from a skeleton

VERTEBRAE 35—Continued

HS 14.

HA 8-9. *Oligocottus rubellio*, page 71.

HA 13-14.

- a. Supraoccipital crest high, sharp pointed.
 - b. Atlas closely joined to skull. Two large downward projecting knobs on prootic. *Damalichthys vacca*, page 61.
- bb. Joint between atlas and skull readily distinguished. Two downward projecting knobs on prootic much less prominent.
 - c. First haemal spine as long as 2nd. Orbit large, greatest vertical diameter $2\frac{1}{4}$ - $2\frac{1}{2}$ in length of skull (from vomer to atlas). *Hyperprosopon argenteum*, page 59.
 - cc. First haemal spine shorter than 2nd. Orbit normal, greatest vertical diameter 3 or more in length of skull (from vomer to atlas). *Micrometrus minimus*, page 61. *Brachyistius frenatus*, page 59.
- aa. Supraoccipital crest very small, almost wanting. *Pleuronichthys ritteri*, page 45.

HS 15.

HA 14.

a. First haemal spine $4-4\frac{1}{2}$ in vertebral column. *Damalichthys vacca*, page 61.aa. First haemal spine 5-6 in vertebral column. *Cymatogaster aggregata*, page 59.

HA 15.

- a. Supraoccipital crest not rising above level of skull. Epiotics and supraoccipital extended posteriorly, ending in brushlike forms. First 3 neural spines flattened into thin fanlike plates. *Fundulus parvipinnis*, page 41.
- aa. Supraoccipital crest rising to a high sharp point. Epiotics, supraoccipital and first 3 neural spines not as above.
 - b. First haemal spine $4-4\frac{1}{2}$ in vertebral column.
 - c. Tonguelike projection on anterior edge of basisphenoid. *Embiotoca jacksoni*, page 61.
 - cc. No tonguelike projection on anterior edge of basisphenoid.
 - d. Atlas closely joined to skull. Two large downward projecting knobs on prootic. *Damalichthys vacca*, page 61.
 - bb. Joint between atlas and skull readily distinguished. Two downward projecting knobs on prootic much less prominent.
 - e. Orbit large, greatest vertical diameter $2\frac{1}{4}$ - $2\frac{1}{2}$ in length of skull (from vomer to atlas). *Hyperprosopon argenteum*, page 59.
 - ee. Orbit normal, greatest vertical diameter 3 in length of skull (from vomer to atlas). *Rhacochilus toxotes*, page 61.
- bb. First haemal spine $5\frac{1}{4}$ -6 in vertebral column. *Micrometrus minimus*, page 61. *Cymatogaster aggregata*, *Zalemmbius rosaceus*, page 59.

HS 16-17; HA 14-16.

- a. Supraoccipital crest not rising above level of skull.
 - b. Epiotics and supraoccipital extended posteriorly, ending in brushlike forms. First 3 neural spines flattened into thin fanlike plates. Length of parapophyses on abdominal vertebrae less than 2 centrums. *Fundulus parvipinnis*, page 41.
- bb. Epiotics, supraoccipital and first 3 neural spines not as above. Parapophyses extremely produced, 4-6 times length of 1 centrum, originating high up on the midline of the centrums and extending outward and curving slightly downward. *Rimicola eigenmanni*, page 75.
- aa. Supraoccipital crest rising to a high sharp point.
 - b. First haemal spine $4-4\frac{1}{2}$ in vertebral column.
 - c. Tonguelike projection on anterior edge of basisphenoid. *Embiotoca jacksoni*, page 61.
 - cc. No tonguelike projection on anterior edge of basisphenoid.
 - d. Atlas closely joined to skull. Two large downward projecting knobs on prootic. *Damalichthys vacca*, page 61.
 - dd. Joint between atlas and skull readily distinguished. Two downward projecting knobs on prootic much less prominent. *Rhacochilus toxotes*, page 61.
- bb. First haemal spine $5\frac{1}{4}$ -6 in vertebral column. *Micrometrus minimus*, page 61. *Cymatogaster aggregata*, *Zalemmbius rosaceus*, page 59.

VERTEBRAE 36

HS 10-11.

HA 6-7. *Paralichthys californicus*, page 41.

HA 8-11.

a. Second haemal spine 14-19 in vertebral column. *Chitonotus pugetensis*, page 69.aa. Second haemal spine 9-11 in vertebral column. *Oligocottus snyderi*, page 71.

HS 12.

HA 8 (See fig. 9).

a. Upper preopercular spine with 3 or 4 barbs hooked upward and forward. *Leptocottus armatus*, page 71.

aa. No such barbed spine.

b. First dorsal spine much longer than 2nd or 3rd. *Chitonotus pugetensis*, page 69.bb. First dorsal spine no longer than 2nd or 3rd. *Oligocottus snyderi*, *Icelinus cavifrons*, page 71.

HA 9-10 (See fig. 9).

a. Second haemal spine 4-5 in vertebral column. *Citharichthys xanthostigmus*, page 43.

aa. Second haemal spine 9-11 in vertebral column.

b. First 2 spines of dorsal fin long and filamentous, much longer than 3rd spine. *Icelinus filamentosus*, page 69.bb. First dorsal spine much longer than 2nd or 3rd. *Chitonotus pugetensis*, page 69.bbb. First dorsal spine no longer than 2nd or 3rd. *Oligocottus snyderi*, *Icelinus cavifrons*, page 71.HA 11. *Oligocottus snyderi*, page 71.

HA 12.

a. Second haemal spine 4-5 in vertebral column. *Platichthys stellatus*, page 47.aa. Second haemal spine 9-11 in vertebral column. *Oligocottus snyderi*, page 71.

HS 13; HA 8-13.

a. Second haemal spine 9-11 in vertebral column. *Oligocottus snyderi*, page 71.

aa. Second haemal spine 4-6 in vertebral column.

b. Supraoccipital crest high, sharp pointed. *Micrometrus minimus*, page 61.

bb. Supraoccipital crest very small, almost wanting.

c. Parapophyses preceding 1st haemal spine short, stubby. (See fig. 10.) *Pleuronichthys ritleri*, page 45.cc. Parapophyses preceding 1st haemal spine long, pointed. (See fig. 11.) *Hypsopsetta guttulata*, page 43.

HS 14; HA 13-14.

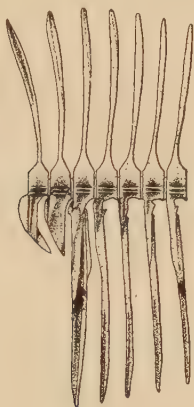
a. Supraoccipital crest high, sharp pointed.

b. First haemal spine 4-4½ in vertebral column.

c. Atlas closely joined to skull. Two large downward projecting knobs on prootic. *Damalichthys vacca*, page 61.cc. Joint between atlas and skull readily distinguished. Two downward projecting knobs on prootic much less prominent. *Hyperprosopon argenteum*, page 59.bb. First haemal spine 5½ in vertebral column. *Micrometrus minimus*, page 61.

aa. Supraoccipital crest very small, almost wanting.

b. Parapophyses preceding 1st haemal spine short, stubby. (See fig. 10.) *Pleuronichthys ritleri*, page 45.bb. Parapophyses preceding 1st haemal spine long, pointed. (See fig. 12.) *Pleuronichthys verticalis*, page 45.

FIGURE 12. *Pleuronichthys verticalis*

VERTEBRAE 36—Continued

HS 15; HA 14-15.

- a. Supraoccipital crest not rising above level of skull. Epiotic and supraoccipital crests extended posteriorly ending in brushlike forms. First 3 neural spines flattened into thin fanlike plates. *Fundulus parvipinnis*, page 41.
- aa. Supraoccipital crest rising to a high sharp point. Epiotics, supraoccipital and first 3 neural spines not as above.
- b. First haemal spine $4-4\frac{1}{2}$ in vertebral column.
 - c. Atlas closely joined to skull. Two large downward projecting knobs on prootic. *Damalichthys vacca*, page 61.
 - cc. Joint between atlas and skull readily distinguished. Two downward projecting knobs on prootic much less prominent.
 - d. Orbit large, greatest vertical diameter $2\frac{1}{4}-2\frac{1}{2}$ in skull (from vomer to atlas). *Hyperprosopon argenteum*, page 59.
 - dd. Orbit normal, greatest vertical diameter 3 in skull (from vomer to atlas). *Rhacochilus toxotes*, page 61.
- bb. First haemal spine $5\frac{1}{4}-6$ in vertebral column.
 - c. Dorsal rays 13-16. *Micrometrus minimus*, page 61
 - cc. Dorsal rays 20. *Cymatogaster aggregata*, page 59.

HS 16.

HA 12-13. *Scorpaenichthys marmoratus*, page 69.

HA 14-16.

- a. Supraoccipital crest very low.
 - b. Supraoccipital and epiotic crests extended posteriorly into brushlike forms. First 3 neural spines flattened into thin fanlike plates. *Fundulus parvipinnis*, page 41.
- bb. Supraoccipital, epiotics and first 3 neural spines not as above. *Clevelandia ios*, page 73.
- aa. Supraoccipital crest high, sharp pointed.
 - b. Supraoccipital crest not extending beyond junction of skull and atlas. *Hypsurus caryi*, page 61.
 - bb. Supraoccipital crest extending beyond junction of skull and atlas.
 - c. First haemal spine $4-4\frac{1}{2}$ in vertebral column.
 - d. Atlas closely joined to skull. Two large downward projecting knobs on prootic. *Damalichthys vacca*, page 61.
 - dd. Joint between atlas and skull readily distinguished. Two downward projecting knobs on prootic much less prominent. *Rhacochilus toxotes*, page 61.
 - cc. First haemal spine $5\frac{1}{4}-6$ in vertebral column.
 - d. Dorsal rays 13-16. *Micrometrus minimus*, page 61.
 - dd. Dorsal rays 20. *Cymatogaster aggregata*, page 59.

HS 17-19.

HA 12-13. *Scorpaenichthys marmoratus*, page 69.

HA 15-19.

- a. Supraoccipital crest very low. *Fundulus parvipinnis*, page 41.
- aa. Supraoccipital crest high, sharp pointed. *Hypsurus caryi*, page 61.

VERTEBRAE 37

HS 11; HA 8-11

- a. Second haemal spine 4-5 in vertebral column. *Citharichthys stigmaeus*, page 43.
- aa. Second haemal spine 8-18 in vertebral column.
 - b. Haemapophyses on vertebra preceding 1st haemal spine the same length as 1st haemal spine and with distal ends enlarged and thickened. *Oligocottus snyderi*, page 71.
 - bb. All haemapophyses much shorter than 1st haemal spine.
 - c. Epiotics without crests. Frontal sloping gradually to vomer. *Hypsoblennius gilberti*, page 77.
 - cc. Epiotics with low thin crests extending forward in a "V" to meet behind orbit. Frontal drops vertically to vomer. *Paraclinus integripinnis*, page 75.

HS 12.

HA 8.

- a. Second haemal spine 5-6 in vertebral column. *Hippoglossina stomata*, page 41.
- aa. Second haemal spine 8-18 in vertebral column.
 - b. Haemapophyses on vertebra preceding 1st haemal spine the same length as 1st haemal spine and with distal ends enlarged and thickened. *Oligocottus snyderi*, page 71.
 - bb. All haemapophyses much shorter than 1st haemal spine. *Hypsoblennius gilberti*, page 77.

HA 9-11.

- a. Second haemal spine 4-6 in vertebral column.
 - b. Haemapophyses as shown in fig. 13. *Citharichthys xanthostigmus*, page 43.

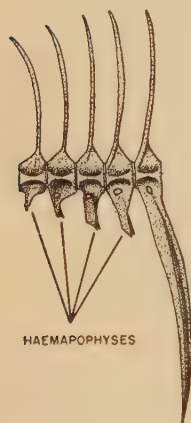


FIGURE 13.
Citharichthys xanthostigmus

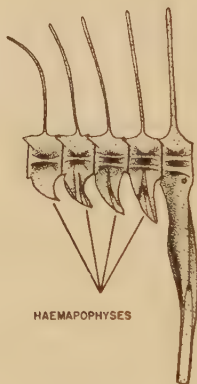


FIGURE 14.
Hippoglossina stomata

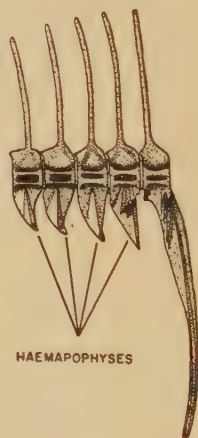


FIGURE 15.
Xystreurus liolepis

- bb. Haemapophyses as shown in figs. 14 and 15.
 - c. Second haemal spine 5-6 in vertebral column. First 12-18 haemal spines pierced by a small hole near the base. *Hippoglossina stomata*, page 41.
 - cc. Second haemal spine 4-5 in vertebral column. No holes near base of haemal spines. *Xystreurus liolepis*, page 41.
- aa. Second haemal spine 8-18 in vertebral column.
 - b. Haemapophyses on vertebra preceding 1st haemal spine same length as 1st haemal spine and with distal ends enlarged and thickened. *Oligocottus snyderi*, page 71.
 - bb. All haemapophyses much shorter than 1st haemal spine.
 - c. Top of skull smooth and rounded, epiotics without crests. Frontal sloping gradually to vomer. *Hypsoblennius gilberti*, page 77.
 - cc. No supraoccipital crest. Epiotics with low thin crests extending forward in a "V" to meet behind orbit. Frontal drops vertically to vomer. *Paraclinus integripinnis*, page 75.

VERTEBRAE 37—Continued

HS 12—Continued

HA 12.

- a. Second haemal spine 4-5 in vertebral column. *Platichthys stellatus*, page 47.
- aa. Second haemal spine 9-11 in vertebral column. *Oligocottus snyderi*, page 71.

HS 13; HA 8-13.

- a. First haemal spine inconspicuous. *Hemilepidotus spinosus*, page 69.
- aa. First haemal spine conspicuous. *Oligocottus snyderi*, page 71.

HS 14; HA 13-14.

- a. Supraoccipital crest high, ending in a sharp point over junction of atlas and 2nd vertebra.
- b. Atlas closely joined to skull. Two large downward projecting knobs on prootic. *Damalichthys vacca*, page 61.
- bb. Joint between atlas and skull readily distinguished. Two downward projecting knobs on prootic much less prominent.
 - c. Orbit large, greatest vertical diameter $2\frac{1}{4}$ - $2\frac{1}{2}$ in skull (from vomer to atlas). *Hyperprosopon argenteum*, page 59.
 - cc. Orbit normal, greatest vertical diameter 3 in skull (from vomer to atlas). *Phanerodon furcatus*, page 61.

aa. Supraoccipital crest very small, almost wanting.

- b. Haemal spines pierced by small hole near base. (See fig. 16.) *Pleuronichthys coenosus*, page 45.

- bb. Haemal spines not pierced by hole near base. (See fig. 12.) *Pleuronichthys verticalis*, page 45.

HS 15-16; HA 14-16.

- a. Supraoccipital and epiotic crests extended posteriorly into brushlike forms. First 3 neural spines flattened into thin fanlike plates. *Fundulus parvipinnis*, page 41.

aa. Supraoccipital, epiotics and first 3 neural spines not as above.

- b. Supraoccipital crest not extending beyond junction of skull and atlas. *Hypsurus caryi*, page 61.

- bb. Supraoccipital crest extending beyond junction of skull and atlas.

c. First haemal spine $4-4\frac{1}{2}$ in vertebral column.

- d. Atlas closely joined to skull. Two large downward projecting knobs on prootic. *Damalichthys vacca*, page 61.

- dd. Joint between atlas and skull readily distinguished. Two downward projecting knobs on prootic much less prominent.

- e. Orbit large, greatest vertical diameter $2\frac{1}{4}$ - $2\frac{1}{2}$ in skull (from vomer to atlas). *Hyperprosopon argenteum*, page 59.

- ee. Orbit normal, greatest vertical diameter 3 in skull (from vomer to atlas).

- f. Dorsal fin IX to X, 20 to 25. Anal fin III, 28 to 30. *Rhacochilus toxotes*, page 61.

- ff. Dorsal fin X to XI, 22 to 26. Anal fin III, 30 to 33. *Phanerodon furcatus*, page 61.

- cc. First haemal spine $5\frac{1}{2}$ -6 in vertebral column. *Cymatogaster aggregata*, page 59.

HS 17-19; HA 15-19.

- a. Supraoccipital crest very low. *Fundulus parvipinnis*, page 41.

- aa. Supraoccipital crest high, sharp pointed. *Hypsurus caryi*, page 61.

VERTEBRAE 38

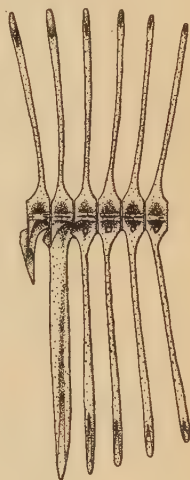
HS 11; HA 8-11.

- a. Second haemal spine 4-5 in vertebral column. *Citharichthys stigmaeus*, page 43.

aa. Second haemal spine 8 or more in vertebral column.

- b. Top of skull smooth, rounded, epiotics without crests. Frontal sloping gradually to vomer. *Hypsoblennius gilberti*, page 77.

- bb. No supraoccipital crest. Epiotics with low thin crests extending forward in a "V" to meet behind orbit. Frontal drops vertically to vomer. *Paraclinus integripinnis*, page 75.

FIGURE 16. *Pleuronichthys coenosus*

VERTEBRAE 38—Continued

HS 12.

HA 8.

- a. Second haemal spine 5-6 in vertebral column. *Hippoglossina stomata*, page 41.
- aa. Second haemal spine 8 or more in vertebral column.
 - b. Haemapophyses preceding 1st haemal spine fused into thin plate projecting backwards. *Icelinus tenuis*, page 69.
 - bb. Haemapophyses preceding 1st haemal spine end in sharp points divergent from each other. *Hypsoblennius gilberti*, page 77.

HA 9-11.

- a. Second haemal spine 4-6 in vertebral column.
 - b. Haemapophyses as shown in fig. 13. *Citharichthys xanthostigmus*, page 43.
- bb. Haemapophyses as shown in figs. 14 and 15.
 - c. Second haemal spine 5-6 in vertebral column. First 12-18 haemal spines pierced by small hole near base. *Hippoglossina stomata*, page 41.
 - cc. Second haemal spine 4-5 in vertebral column. No holes near bases of haemal spines. *Xystreurus hiolepis*, page 41.
- aa. Second haemal spine 8 or more in vertebral column.
 - b. Top of skull smooth and rounded, epiotics without crests. Frontal sloping gradually to vomer. *Hypsoblennius gilberti*, page 77.
 - bb. No supraoccipital crest. Epiotics with low thin crests extending forward in a "V" to meet behind orbit. Frontal drops vertically to vomer. *Paraclinus integripinnis*, page 75.

HS 13; HA 11. *Radulinus asprellus*, page 69.

HS 14; HA 13-14.

- a. Supraoccipital crest high, ending in a sharp point over junction of atlas and 2nd vertebra.
 - b. Atlas closely joined to skull. Two large downward projecting knobs on prootic. *Damalichthys vacca*, page 61.
- bb. Joint between atlas and skull readily distinguished. Two downward projecting knobs on prootic much less prominent.
 - c. Orbit large, greatest vertical diameter $2\frac{1}{4}$ - $2\frac{1}{2}$ in skull (from vomer to atlas). *Hyperprosopon argenteum*, page 59.
 - cc. Orbit normal, greatest vertical diameter 3 in skull (from vomer to atlas). *Phanerodon furcatus*, page 61.
- aa. Supraoccipital crest very small, almost wanting. *Pleuronichthys coenosus*, page 45.

HS 15-16; HA 14-16.

- a. Supraoccipital crest not extending beyond junction of skull and atlas. *Hypsurus caryi*, page 61.
- aa. Supraoccipital crest extending beyond junction of skull and atlas.
 - b. First haemal spine $4\frac{1}{4}$ in vertebral column.
 - c. Atlas closely joined to skull. Two large downward projecting knobs on prootic. *Damalichthys vacca*, page 61.
 - cc. Joint between atlas and skull readily distinguished. Two downward projecting knobs on prootic much less prominent.
 - d. Orbit large, greatest vertical diameter $2\frac{1}{4}$ - $2\frac{1}{2}$ in skull (from vomer to atlas). *Hyperprosopon argenteum*, page 59.
 - dd. Orbit normal, greatest vertical diameter 3 in skull (from vomer to atlas). *Phanerodon furcatus*, page 61.
 - bb. First haemal spine $5\frac{1}{2}$ -6 in vertebral column. *Cymatogaster aggregata*, page 59.

HS 17-19; HA 16-19. *Hypsurus caryi*, page 61.

VERTEBRAE 39.¹

HS 12-13.

HA 9-10. *Citharichthys sordidus*, page 43.HA 11. *Radulinus asprellus*, page 69.

HS 14; HA 13-14.

- a. Supraoccipital crest high, ending in a sharp point over junction of atlas and 2nd vertebra.
- b. Atlas closely joined to skull. Two large downward projecting knobs on prootic. *Damalichthys vacca*, page 61.
- bb. Joint between atlas and skull readily distinguished. Two downward projecting knobs on prootic much less prominent. *Phanerodon furcatus*, page 61.
- aa. Supraoccipital crest very small, almost wanting. *Pleuronichthys coenosus*, page 45.

HS 15-16; HA 14-16.

- a. Supraoccipital crest high, ending in a sharp point over junction of atlas and 2nd vertebra.
- b. Atlas closely joined to skull. Two large downward projecting knobs on prootic. *Damalichthys vacca*, page 61.
- bb. Joint between atlas and skull readily distinguished. Two downward projecting knobs on prootic much less prominent. *Phanerodon furcatus*, page 61.
- aa. Supraoccipital crest very small, almost wanting. *Pleuronichthys decurrens*, page 45.

Sudden increase in length of haemal spine on vertebra No. 19.

HA 9-12.

- a. First haemal arch bent forward forming an angle of 45° or less with vertebral column. *Thunnus germon*, page 53.
- aa. First haemal arch only slightly bent forward.
- b. Alisphenoids extending down more than half way into interorbital opening (see fig. 17). *Thunnus thynnus*, page 55.
- bb. Alisphenoids extending less than half way into interorbital opening (see fig. 17). *Neothunnus macropterus*, page 55.



NEOTHUNNUS MACROPTERUS



THUNNUS THYNNUS

FIGURE 17. Showing differences between *Neothunnus macropterus* and *Thunnus thynnus*

¹ In *Thunnus thynnus*, *Thunnus germon*, *Neothunnus macropterus* and *Sarda lineolata*, the first haemal spine is indeterminate because of a gradual increase in length of the haemal processes. However, there is a point where the haemal spine length suddenly changes from short to long. The vertebra on which this sudden increase occurs was selected as the diagnostic character.

VERTEBRAE 39—Continued

HS 19-20; HA 19-20. See plate II for differences in parapophyses, haemapophyses and haemal spines. *Anchoa compressa*, *Anchoa delicatissima*, page 37.

HS 21-22; HA 20-22.

a. Last few caudal vertebrae without spines and keeled. *Auzis thazard*, page 53.

aa. Last few caudal vertebrae with spines and without keel. *Anchoa delicatissima*, page 37.

HS 24; HA 24. *Vinciguerria lucetia*, page 39.

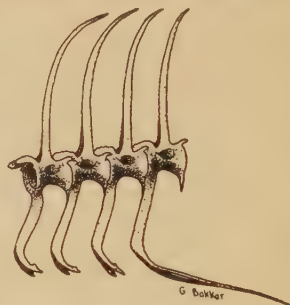


FIGURE 18. Showing the parapophyses and the first haemal spine of *Auzis thazard*

VERTEBRAE 40.

HS 12-13; HA 9-12.

a. First haemal arch and first haemal spine on same vertebra. First haemal spine and parapophyses preceding it as in fig. 19. *Lepidopsetta bilineata*, page 45.

aa. First haemal arch on 2nd to 4th vertebra in front of 1st haemal spine. First haemal spine and haemapophyses preceding it as in fig. 19. *Citharichthys sordidus*, page 43.

HS 14-16; HA 13-16.

a. Supraoccipital crest high, ending in a sharp point over junction of atlas and 2nd vertebra. *Phanerodon furcatus*, page 61.

aa. Supraoccipital crest very small, almost wanting. *Pleuronichthys decurrens*, page 45.

HS 19-20; HA 19-20. See plate II for differences in parapophyses, haemapophyses and haemal spines. *Anchoa compressa*, *Anchoa delicatissima*, page 37.

HS 21-22.

HA 20-21. *Anchoa delicatissima*, page 37.

HA 22.

a. Haemal spines with an offset as in plate II. *Cetengraulis mysticetus*, page 37.

aa. Haemal spines straight as in plate II. *Anchoa delicatissima*, page 37.

HS 23; HA 23. *Cetengraulis mysticetus*, page 37.

HS 24; HA 24. *Vinciguerria lucetia*, page 39.

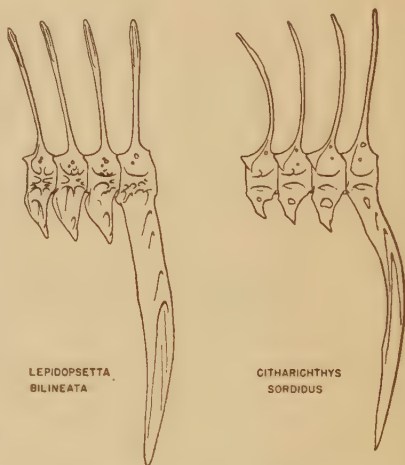


FIGURE 19. Showing the first haemal spine and the preceding parapophyses of *Lepidopsetta bilineata* and the first haemal spine and the preceding haemapophyses of *Citharichthys sordidus*

VERTEBRAE 41

HS 14-16.

HA 11-13.

a. Second neural spine shorter than 3rd. *Zaniolepis frenatus*, page 69.

aa. Second neural spine longer than 3rd. *Zaniolepis latipinnis*, page 69.

HA 13-16. *Phanerodon furcatus*, page 61.

HS 19-20.

HA 16. *Tarletonbeania crenularis*, page 39.

HA 19-20. See plate II for differences in parapophyses, haemapophyses and haemal spines. *Anchoa compressa*, *Anchoa delicatissima*, page 37.

HS 21-22.

HA 12-13. *Katsuwonus pelamis*, page 53.

HA 20-22.

a. Haemal spines with an offset as in plate II. *Cetengraulis mysticetus*, page 37.

aa. Haemal spines straight as in plate II. *Anchoa delicatissima*, page 37.

HS 23; HA 23. *Cetengraulis mysticetus*, page 37.

VERTEBRAE 42-43

HS 11-13.

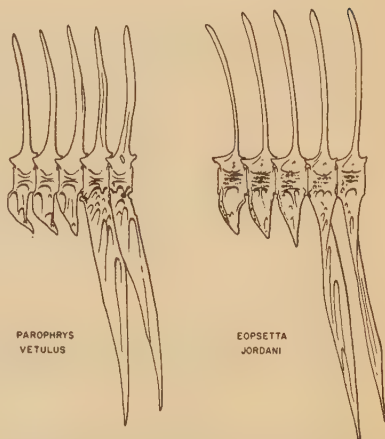
HA 8-12.

- a. First haemal spine 15-16 in vertebral column. Vomer with 2 curved fang-like teeth. *Porichthys notatus*, page 73.
- aa. First haemal spine 5-6 in vertebral column. No fanglike teeth on vomer.
- b. Longest neural spine 8-9 in vertebral column. First 2 haemal spines widened, the 1st partly inclosed by 2nd. (See fig. 20.) First 10-15 haemal spines pierced by a small hole near bases. *Parophrys vetulus*, page 45.
- bb. Longest neural spine 7-8 in vertebral column. First 2 haemal spines not enlarged, well separated. (See fig. 20.) Bases of haemal spines not pierced by a hole. *Eopsetta jordani*, page 43.

HA 13. *Odontopyxis trispinosa*, page 71.

HS 15-16; HA 11-13.

- a. Second neural spine shorter than 3rd. *Zaniolepis frenatus*, page 69.

aa. Second neural spine longer than 3rd. *Zaniolepis latipinnis*, page 69.HS 22-23; HA 22-23. *Cetengraulis mysticetus*, page 37.FIGURE 20. Showing the first two haemal spines and the preceding haemapophyses of *Parophrys vetulus* and *Eopsetta jordani*

VERTEBRAE 44. See footnote, page 27.

HS 11-13.

HA 8-10. (See fig. 21.) *Porichthys notatus*, page 73.HA 12. *Parophrys vetulus*, page 45.HA 13. *Lyopsetta exilis*, page 43.

First sudden increase in the length of haemal spines on vertebra 22-24.

HA 12-14. *Sarda lineolata*, page 53.HS 25-27; HA 25-27. *Engraulis mordax*, page 37.

VERTEBRAE 45. See footnote, page 27.

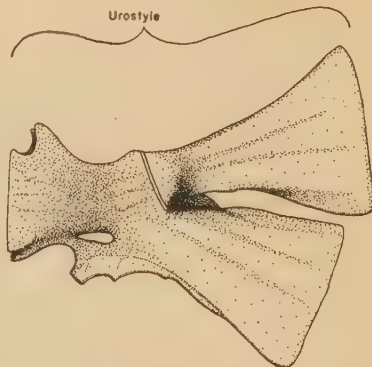
HS 11-13.

HA 8-10. (See fig. 21.) *Porichthys notatus*, page 73.HA 12. *Parophrys vetulus*, page 45.HA 13. *Lyopsetta exilis*, page 43.

HS 22-27 or first sudden increase in length of haemal spines on vertebra 22-27.

HA 12-16.

- a. Haemal and neural spines on the last 6 vertebrae short, lying flat, in close contact with centrums. *Sarda lineolata*, page 53.

aa. All haemal and neural spines long, standing well out from centrums. *Opisthonema libertate*, page 37.HA 25-27. *Engraulis mordax*, page 37.FIGURE 21. The urostyle of *Porichthys* showing the joint in the upper lobe

VERTEBRAE 46. See footnote, page 27.

HS 11-13.

HA 10-11. (See fig. 21.) *Porichthys myriaster*, page 75.HA 13. *Lyopsetta exilis*, page 43.HS 15; HA 12-13. *Neoclinus satiricus*, page 75.

HS 22-27 or first sudden increase in length of haemal spines on vertebra 22-27.

HA 12-16.

a. Haemal and neural spines on the last 6 vertebrae short, lying flat, in close contact with centrums. *Sarda lineolata*, page 53.aa. All haemal and neural spines long, standing well out from centrums. *Opisthonema libertate*, page 37.HA 25-27. *Engraulis mordax*, page 37.HS 34-38; HA 22-24. *Atherinops affinis*, page 49.

VERTEBRAE 47

HS 12-13.

HA 10-11. (See fig. 21.) *Porichthys myriaster*, page 75.HA 13. *Lyopsetta exilis*, page 43.HS 15; HA 12-13. *Neoclinus satiricus*, page 75.

HS 20-22; HA 12-14.

a. Posterior extension of line drawn along anterior midline of skull falls below upper edge of supraoccipital crest. *Scomberomorus sierra*, page 53.aa. Posterior extension of line drawn along anterior midline of skull coincides with, or is above, upper edge of supraoccipital crest. *Scomberomorus concolor*, page 53.

HS 23-27.

HA 14-16. *Opisthonema libertate*, page 37.HA 25-27. *Engraulis mordax*, page 37.HS 31-33; HA 24-26. *Argentina sialis*, page 37.HS 34-38; HA 22-24. *Atherinops affinis*, page 49.

VERTEBRAE 48

HS 12-13; HA 10-11. (See fig. 21.) *Porichthys myriaster*, page 75.

HS 15.

HA 12-13.

a. Two spines in anal fin. *Neoclinus blanchardi*, page 75.aa. No spines in anal fin. *Neoclinus satiricus*, page 75.HS 17-19; HA 16-19. *Gibbonsia elegans*, page 75.

HS 20-22; HA 12-14.

a. Posterior extension of line drawn along anterior midline of skull falls below upper edge of supraoccipital crest. *Scomberomorus sierra*, page 53.aa. Posterior extension of line drawn along anterior midline of skull coincides with, or is above, upper edge of supraoccipital crest. *Scomberomorus concolor*, page 53.

HS 31-33.

HA 24-26. *Argentina sialis*, page 37.HA 33. *Cypselurus californicus*, page 39.

HS 34-38.

HA 22-26. *Atherinops affinis*, *Leuresthes tenuis*, page 49.HA 34-37. *Cypselurus californicus*, page 39.HS 39-40; HA 23-25. *Leuresthes tenuis*, page 49.

VERTEBRAE 49

HS 12-13; HA 10-11. (See fig. 21.) *Porichthys myriaster*, page 75.HS 15; HA 12-13. *Neoclinus satiricus*, page 75.HS 17-19; HA 16-19. *Gibbonsia elegans*, page 75.HS 21-22; HA 12-14. *Scomberomorus sierra*, page 53.

HS 29-32; HA 20-26.

a. Small splinter of bone projecting forward from haemapophyses parallel, or nearly parallel, to vertebral column.

b. Parasphenoid extending backward as 2 wide thin wings under 1st 3 vertebrae. *Clupea pallasii*, page 35.bb. Parasphenoid extending backward as 2 narrow thin wings under 1st 3 vertebrae. *Sardinops caerulea*, page 35.aa. No such splinter of bone. *Argentina sialis*, page 37.

VERTEBRAE 49—Continued

HS 33.

HA 24-26. *Argentina sialis*, page 37.HA 33. *Cypselurus californicus*, page 39

HS 34-38.

HA 22-25. *Atherinops affinis*, *Leuresthes tenuis*, page 49.HA 34-37. *Cypselurus californicus*, page 39.HS 39-40; HA 23-25. *Leuresthes tenuis*, page 49

VERTEBRAE 50-55

HS 4; HA 4. Haemal spine suddenly increasing in length on vertebra 10. *Symphurus atricaudus*, page 47.HS 12-14; HA 6-7. *Microstomus pacificus*, page 47.HS 17; HA 15-17. *Gibbonsia montereyensis*, page 75HS 19-20; HA 18-20. *Gibbonsia metzi*, page 75.

HS 24-26.

HA 24-26.

a. Parapophyses greatly elongated and thickened. *Merluccius productus*, page 41.aa. All parapophyses except the last pair normal. *Aulorhynchus flavidus*, page 72.HS 27; HA 27. *Aulorhynchus flavidus*, page 72.

HS 29-32.

HA 20-24.

a. Parasphenoid extending backward as 2 wide thin wings under 1st 3 vertebrae. *Clupea pallasii*, page 35.aa. Parasphenoid extending backward as 2 narrow thin wings under 1st 3 vertebrae. *Sardinops caerulea*, page 35.

HS 33-38.

HA 17-19. *Etrumeus orthonops*, page 35.HA 22-24. *Atherinops affinis*, page 49.HA 33-37. *Cypselurus californicus*, page 39.HS 40-42; HA 23-25. *Atherinopsis californiensis*, page 49

VERTEBRAE 56-58

HS 23; HA 23. *Heterostichus rostratus*, page 75.HS 24-25; HA 22-23. *Ophiodon elongatus*, page 69.HS 26-27; HA 26-27. *Aulorhynchus flavidus*, page 72.HS 30; HA 19-20. *Alosa sapidissima*, page 35.

VERTEBRAE 60-64

HS 14-15; HA 14-15. *Glyptocephalus zachirus*, page 47.HS 31-33; HA 27-30. *Anaplopoma fimbria*, page 69.

HS 36-40 or first sudden increase in length of haemal spines occurs on vertebra 36-40.

HA 28-30. Haemal spines similar to those of the tuna. See footnote, page 27. *Onco-rhynchus tschawytcha*, page 37.HA 38-40. Haemal spines normal. *Cololabis saira*, page 39.HS 50-55; HA 50-55. *Synodus lucioceps*, page 39.

VERTEBRAE 65-72

HS indeterminate (see page 7); HA 43-46. *Albula vulpes*, page 35.HS 16-18; HA 16-18. *Otophidium scrippsi*, page 79.

HS 22-25.

HA 22-25.

a. Neural spines 1-32 are thin, ribbed plates. *Syngnathus californiensis*, page 72.aa. All neural spines normal. *Cebidichthys violaceus*, page 77.HS 31-33; HA 27-30. *Anaplopoma fimbria*, page 69.

VERTEBRAE 65-72—Continued

HS 36-40, or first sudden increase in length of haemal spines occurs on vertebra 36-40.

HA 28-30. Haemal spines similar to those of the tuna. See footnote, page 27. *Onco-rhynchus tschawytcha*, page 37.

HA 38-40. Haemal spines normal. *Cololabis saira*, page 39.

HS 45-51; HA 43-51. *Tylosurus exilis*, page 39.

VERTEBRAE 73-77

HS indeterminate (see page 7); HA 43-46. *Albula vulpes*, page 35.

HS 22-25; HA 22-25.

a. Neural spines 1-32 are thin, ribbed plates. *Syngnathus californiensis*, page 72.

aa. All neural spines normal.

b. Skull elongated and concave over cranium. Depth at cranium 4 in length between atlas and vomer. *Epigee-ichthys atro-purpureus*, page 77.

bb. Skull shorter and convex over cranium. Depth at cranium $2\frac{1}{2}$ in length between atlas and vomer. *Cebidichthys violaceus*, page 77.

HS 45-51; HA 43-51. *Tylosurus exilis*, page 39.

VERTEBRAE 79-80; HS 53-54; HA 50-52. *Elops affinis*, page 35.

VERTEBRAE 84-90

HS 5; HA 5. *Xerperes fucorum*, page 77.

HS 19; HA 19. *Otophidium taylori*, page 79.

HS 20-21; HA 20-21.

a. A hemispherical structure attached to the 4th and 5th vertebrae. See page 79. *Otophidium taylori*, page 79.

aa. No such structure. *Melanostigma pammelas*, page 79.

VERTEBRAE 92; HS 38; HA 38. *Trachypterus rex-salmonorum*, page 41.

VERTEBRAE 104-107

HS 22-23; HA 22-23. *Lycodopsis pacifica*, page 77.

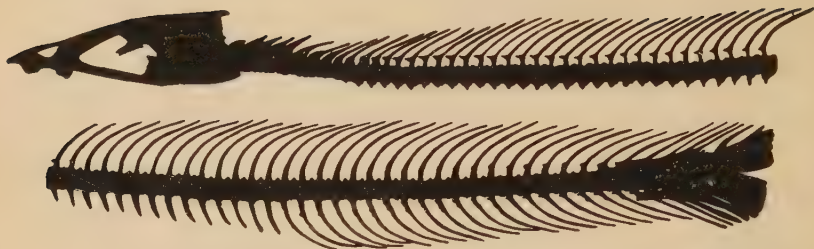
HS 52-54; HA 4-5. *Ulvicola sanctae-rosae*, page 77.

VERTEBRAE 146-150; HS 77-80; HA 76-80. *Gymnothorax mordax*, page 39.VERTEBRAE over 230; HS 39; HA 39. *Anarrichthys ocellatus*, page 77.

FIGURE 22. Ventral view of the skull of *Albula vulpes* showing the large grinding teeth on the parasphenoid

DESCRIPTIONS AND ILLUSTRATIONS

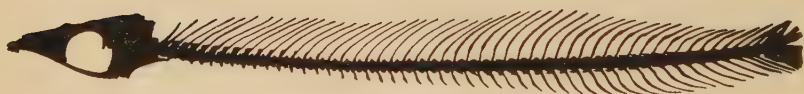
Figures in parentheses indicate number of specimens



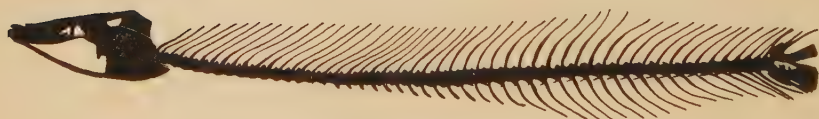
ELOPS AFFINIS



ALBULA VULPES



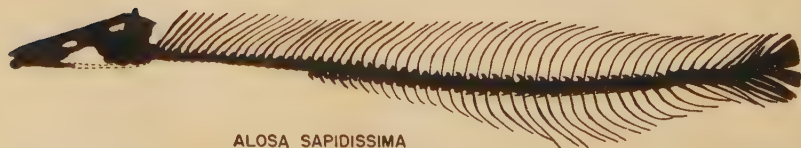
ETRUMEUS OTHONOPS



CLUPEA PALLASII



SARDINOPS CAERULEA



ALOSA SAPIDISSIMA

Elops affinis Regan. Tenpounder.

The numerous vertebrae have short thin haemal and neural spines curved backward. The skull is elongated.

Individuals examined: 2 from the Salton Sea. Total vertebrae 79 (1), 80 (1); first haemal spine 53 (1), 54 (1); first haemal arch 50 (1), 52 (1). Dorsal 20; anal 13.

Albula vulpes (Linnaeus). Bonefish.

The first haemal spine is indeterminate because the haemal processes fuse at the base only and remain bifurcate throughout. There are very large massive molars on back of tongue and on palatines and parasphenoid. (See fig. 22.)

Individuals examined: 1 from Pt. Mugu, 1 from Redondo Beach, 2 from San Pedro fish markets, 1 from Newport Bay, 3 from San Juanico Bay, 4 from Magdalena Bay, Lower California, and 5 post larvae from San Felipe Bay, Gulf of California. Total vertebrae 71 (4), 72 (9), 73 (3), 74 (1); first haemal spine indeterminate; first haemal arch 43 (1), 44 (6), 45 (7), 46 (3). Dorsal 15 to 20; anal 5 to 10.

Etrumeus orthonops (Eigenmann). Round Herring.

The bones forming the bridges of the haemal arches gradually thicken dorso-ventrally. At the same time the extensions of the haemapophyses draw together until the first haemal spine is formed. Therefore, the first haemal spine is obscured.

Individuals examined: 6 from San Pedro fish markets, 5 from vicinity of San Pedro, 2 from off Oceanside and 1 from Magdalena Bay, Lower California. Total vertebrae 53 (2), 54 (11), 55 (1); first haemal spine 35 (2), 36 (8), 37 (3), ? (1); first haemal arch 17 (2), 18 (11), 19 (1). Dorsal 18 to 20; anal 17 to 19.

Clupea pallasii Valenciennes. Pacific Herring.

Individuals examined: 1 from San Pedro fish markets, 2 from off Newport Beach and 3 from Monterey Bay. Total vertebrae 50 (1), 51 (1), 52 (4); first haemal spine 30 (3), 31 (2), 32 (1); first haemal arch 22 (1), 23 (3), 24 (2). Dorsal 16 to 17; anal 14 to 15. Known vertebral range for Southern California specimens 49-53.

Sardinops caerulea (Girard). Pacific Sardine.

The haemapophyses on the caudal vertebrae have a splinter of bone extending forward parallel to the vertebral column. The bones forming the bridges of the haemal arches gradually thicken dorso-ventrally. At the same time the extensions of the haemapophyses draw together until the first haemal spine is formed. Therefore, the first haemal spine is obscured.

Individuals examined: 10 from Oceanside to San Pedro. Total vertebrae 50 (1), 51 (5), 52 (4); first haemal spine 29 (2), 30 (6), 31 (2); first haemal arch 20 (2), 21 (5), 22 (2), 23 (1). Dorsal 17 to 20; anal 17 to 20. Known vertebral range 49-54.

Alosa sapidissima (Wilson). Shad.

All haemal and neural spines are long and thin. Haemal and neural zygapophyses are prominent. The bones forming the bridges of the haemal arches gradually thicken dorso-ventrally. At the same time the extensions of the haemapophyses draw together until the first haemal spine is formed. Therefore, the first haemal spine is obscured.

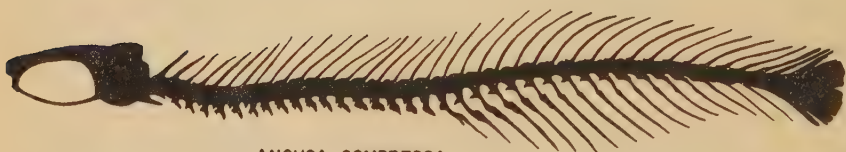
Individuals examined: 1 from off Oceanside and 4 from north of Pt. Conception. Total vertebrae 56 (3), 57 (2); first haemal spine 30 (5); first haemal arch 19 (1), 20 (4). Dorsal 15 to 17; anal 19 to 21.



OPISTHONEMA LIBERTATE



ENGRAULIS MORDAX



ANCHOA COMPRESSA



ANCHOA DELICATISSIMA



CETENGRAULIS MYSTICETUS

Opisthonema libertate (Günther). Thread Herring.

The neural spines on the abdominal vertebrae are exceptionally long.

Individuals examined: 12 from Lower California waters, 1 from San Pedro fish markets and 1 from Seal Beach. Total vertebrae 45 (2), 46 (9), 47 (3); first haemal spine 23 (2), 24 (9), 25 (3); first haemal arch 14 (1), 15 (12), 16 (1). Dorsal 17; anal 19.

Engraulis mordax Girard. Northern Anchovy.

The neural spines on the abdominal vertebrae are short. The first haemal arch and the first haemal spine are on the same vertebra.

Individuals examined: 10 from San Pedro fish markets. Total vertebrae 44 (1), 45 (2), 46 (7); first haemal spine 25 (2), 26 (4), 27 (4); first haemal arch 25 (2), 26 (4), 27 (4). Dorsal 14; anal 22. Known vertebral range 44-47.

Anchoa compressa (Girard). Deep-bodied Anchovy.

The haemal spines have offsets a short distance out from the centrums. The first haemal arch and the first haemal spine are nearly always on the same vertebra. The very large interorbital opening runs far forward. The parasphenoid is very thin and fragile.

Individuals examined: 18 from San Pedro fish markets. Total vertebrae 39 (1), 40 (11), 41 (6); first haemal spine 19 (9), 20 (9); first haemal arch 19 (10), 20 (8). Dorsal 12; anal 31.

Anchoa delicatissima (Girard). Slough Anchovy.

The haemal spines are straight without offsets. The first haemal arch and the first haemal spine are nearly always on the same vertebra. The very large interorbital opening runs far forward, though not as far as in *A. compressa*. The parasphenoid is thin.

Individuals examined: 14 from Long Beach Harbor. Total vertebra 39 (9), 40 (8), 41 (3); first haemal spine 20 (4), 21 (9), 22 (1); first haemal arch 20 (5), 21 (8), 22 (1). Dorsal 13; anal 23.

Cetengraulis mysticetus (Günther). Anchovetta.

The haemal spines have offsets a short distance out from the centrums. The interorbital opening is very large and located well forward. The parasphenoid is thin and compressed laterally. The atlas is very small and short. The first haemal arch and the first haemal spine are on the same vertebra.

Individuals examined: 1 from Long Beach Harbor and 9 from Guaymas, Mexico. Total vertebrae 40 (1), 41 (5), 42 (4); first haemal spine 22 (5), 23 (5); first haemal arch 22 (3), 23 (7). Dorsal 15 to 17; anal 20 to 22.

Oncorhynchus tshawytscha (Walbaum). King Salmon (not illustrated).

The atlas is partially covered by the bones of the prootic region but may be distinguished by the neural spine attached to it. The first haemal spine is similar to that of the tunas and for that reason is not used in this key. The tail is heterocercal, the lower lobe of the urostyle originating from the penultimate vertebra.

Individuals examined: 7 from the San Joaquin River. Total vertebrae 64 (2), 65 (2), 66 (3); first haemal spine not used in this key; first sudden increase in the length of the haemal spines 36 (2), 37 (3), 38 (1), 39 (1); first haemal arch 28 (1), 29 (2), 30 (4). Dorsal 11; anal 15 to 17.

Argentina sialis Gilbert (not illustrated).

Individuals examined: 5 from Oceanside, 4 from Rincon Pt. near Santa Barbara, 1 from Pt. Vicente and 1 from Pismo Beach. Total vertebrae 47 (2), 48 (3), 49 (6); first haemal spine 31 (2), 32 (8), 33 (1); first haemal arch 24 (1), 25 (7), 26 (3). Dorsal 10 to 11; anal 12 to 14.

Cyclothone acclinidens Garman (not illustrated).

The first haemal arch and the first haemal spine are on the same vertebra. The atlas is $1\frac{1}{4}$ to $1\frac{1}{2}$ times longer than the second vertebra and carries a pair of parapophyses while the second vertebra has no parapophyses.

Individuals examined: 4 specimens, locality unknown. Total vertebrae 31 (3), 32 (1); first haemal spine 14 (1), 15 (3); first haemal arch 14 (1), 15 (3).



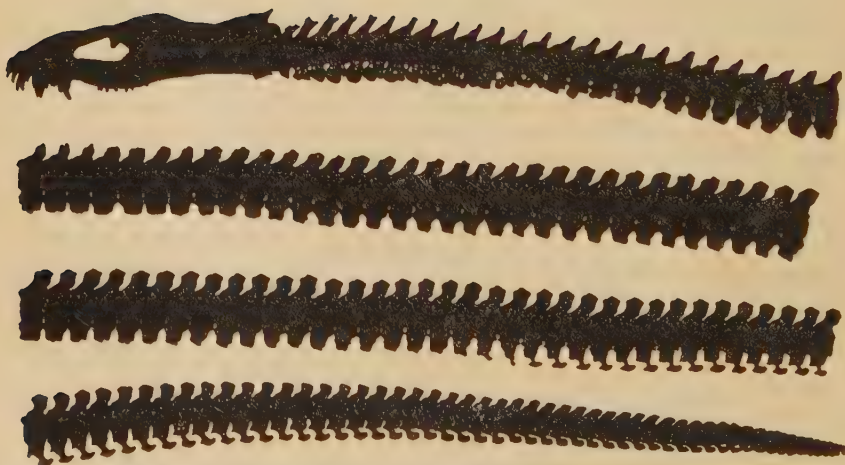
COLOLABIS SAIRA



CYPSELURUS CALIFORNICUS



SYNODUS LUCIOCEPS



GYMNOTHORAX MORDAX

Vinciguerria lucetia (Garman) (not illustrated).

Individuals examined: 2 from stomach of a skipjack taken at Roca Partida near Socorro Island. Total vertebrae 39 (1), 40 (1); first haemal spine 24 (2); first haemal arch 24 (2). Dorsal 13 to 14; anal 13 to 14.

Cololabis saira (Brevoort). Saury.

The first haemal arch and the first haemal spine are on the same vertebra. The neural zygapophyses are produced into antlerlike processes. The haemal and neural spines on the caudal peduncle lie close to the centrums.

Individuals examined: 1 from Santa Cruz Island, 12 from Anacapa Island, 1 from off Ventura and 4 from vicinity of San Pedro. Total vertebrae 63 (3), 64 (4), 65 (11); first haemal spine 38 (1), 39 (13), 40 (4); first haemal arch 38 (1), 39 (13), 40 (4). Dorsal 9-VI; anal 12 to 15-VI.

Tylosurus exilis (Girard). California Needlefish (not illustrated).

The skull is extremely elongated and the vertebrae numerous. The haemal and neural spines are very short. The first haemal arch and the first haemal spine are on the same vertebra.

Individuals examined: 3 from Mission Bay, San Diego, 1 from Newport Bay and 5 from vicinity of San Pedro. Total vertebrae 71 (2), 72 (4), 73 (1), 74 (2); first haemal spine 45 (1), 46 (3), 47 (4), 51 (1); first haemal arch 45 (1), 46 (3), 47 (4), 51 (1). Dorsal I, 12 to 15; anal I, 15 to 19.

Cypselurus californicus (Cooper). California Flying Fish.

The first haemal arch and the first haemal spine are on the same vertebra. There is a sharp decrease in the length of the neural spines about 4 vertebrae anterior to the first haemal arch.

Individuals examined: 10 from San Pedro fish markets, 5 from Santa Cruz Island. Total vertebrae 48 (1), 49 (5), 50 (7), 51 (2); first haemal spine 33 (2), 34 (4), 35 (7), 37 (2); first haemal arch 33 (2), 34 (4), 35 (7), 37 (2). Dorsal 11 to 12; anal 10 to 12.

Synodus lucioceps (Ayres). Lizardfish.

The first haemal arch and the first haemal spine are on the same vertebra. The haemal zygapophyses are long and heavy.

Individuals examined: 3 from San Pedro fish markets, 2 from Santa Barbara, 1 from Malibu, 1 from Newport Bay, 1 from San Diego, 5 from Cedros Island and 2 from San Quintin, Lower California. Total vertebrae 60 (2), 61 (4), 62 (6), 63 (3); first haemal spine 50 (1), 51 (1), 52 (1), 53 (10), 54 (1), 55 (1); first haemal arch 50 (1), 51 (1), 52 (1), 53 (10), 54 (1), 55 (1). Dorsal 11 to 12; anal 12 to 14.

Tarletonbeania crenularis (Jordan and Gilbert). Lanternfish (not illustrated).

Individuals examined: 2 taken from albacore stomachs at Monterey fish markets. Total vertebrae 41 (2); first haemal spine 19 (1), 20 (1); first haemal arch 16 (2). Dorsal 11 to 14; anal 17 to 19.

Gymnothorax mordax (Ayres). Moray.

The parapophyses and the haemal and neural spines are modified into short, wide, rounded plates. The haemal spines have a thin short extension ending in a backward-projecting plate. All the vertebrae are heavy and stout.

Individuals examined: 1 from Guadalupe Island, 1 from San Diego and 2 from the vicinity of San Pedro. Total vertebrae 146 (1), 148 (1), 150 (2); first haemal spine 77 (1), 79 (1), 80 (1), ? (1); first haemal arch 76 (1), 79 (2), 80 (1).



FUNDULUS PARVIPINNIS



Lateral View



Ventral View

MERLUCCIUS PRODUCTUS



HIPPOGLOSSINA STOMATA



PARALICHTHYS CALIFORNICUS



XYSTREURYS LIOLEPIS

Fundulus parvipinnis Girard. Killifish.

The first five neural spines are expanded into thin plates with the first three touching. The supraoccipital and epiotics are extended posteriorly into brushlike forms. The first haemal spine and the first haemal arch are nearly always on the same vertebra. The parapophyses preceding the first haemal spine are long and pointed.

Individuals examined: 14 from the vicinity of San Pedro and Newport Beach and 8 from Tijuana Slough. Total vertebrae 35 (3), 36 (12), 37 (7); first haemal spine 15 (1), 16 (15), 17 (6); first haemal arch 15 (1), 16 (21). Dorsal 13 to 14; anal 11 to 12.

Merluccius productus (Ayres). Hake.

The parapophyses on vertebrae 7 to 23 are extended out and down from the centrums and greatly thickened fore and aft so that they form an almost continuous bony structure roofing the abdominal cavity. The first haemal arch and the first haemal spine are on the same vertebra.

Individuals examined: 9 from Santa Catalina Island, 3 from vicinity of San Pedro and 1 from off Pismo Beach. Total vertebrae 52 (2), 53 (7), 54 (3), 55 (1); first haemal spine 24 (4), 25 (7), 26 (2); first haemal arch 24 (4), 25 (7), 26 (2). Dorsal 11-41; anal 43.

Trachypterus rex-salmonorum Jordan and Gilbert. King of the Salmon (not illustrated).

The first haemal spine and the first haemal arch are on the same vertebra. The atlas is very short. The anterior vertebrae are deeply and finely fluted longitudinally, and are short, gradually increasing in length in the middle section of the body. The posterior vertebrae are greatly elongated. All the vertebrae are fragile and light.

Individuals examined: 1 from a load of sardines taken off Pt. Dume. Total vertebrae 92 (1); first haemal spine 38 (1); first haemal arch 38 (1). Dorsal III, 173; anal absent.

Hippoglossina stomata Eigenmann and Eigenmann. Bigmouth Sole.

The first 12 to 18 haemal spines are pierced laterally by a small hole close to the centrum.

Individuals examined: 4 from San Pedro fish markets and 1 from Newport Beach. Total vertebrae 37 (1), 38 (4); first haemal spine 12 (5); first haemal arch 8 (1), 9 (1), 10 (3). Dorsal 65 to 70; anal 50 to 54.

Paralichthys californicus (Ayres). California Halibut.

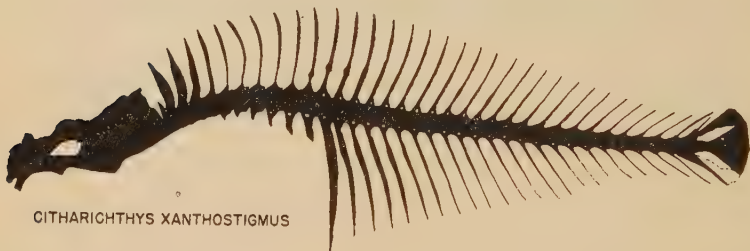
Individuals examined: 17 from vicinity of San Pedro. Total vertebrae 34 (2), 35 (13), 36 (2); first haemal spine 10 (2), 11 (15); first haemal arch 6 (7), 7 (10). Dorsal 68 to 74; anal 52 to 58.

Xystreurys liolepis Jordan and Gilbert. Fantail Sole.

Individuals examined: 1 from Gaviota, 6 from vicinity of San Pedro, 2 from Newport Beach and 1 from San Pedro fish markets. Total vertebrae 37 (1), 38 (9); first haemal spine 12 (10); first haemal arch 9 (7), 10 (3). Dorsal 73 to 80; anal 57 to 62.



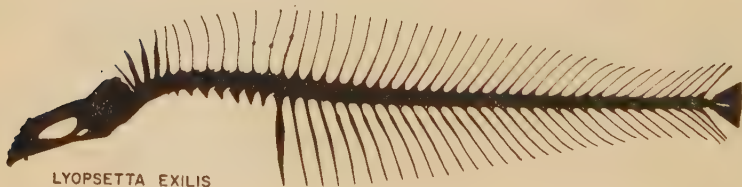
CITHARICHTHYS SORDIDUS



CITHARICHTHYS XANTHOSTIGMUS



CITHARICHTHYS STIGMAEUS



LYOPSETTA EXILIS



HYP SOPSETTA GUTTULATA

Citharichthys sordidus (Girard). Sand dab.

Individuals examined: 11 from Santa Cruz Island, 10 from Pt. Vicente and 1 from Soledad Bay, Lower California. Total vertebrae 39 (12), 40 (10); first haemal spine 12 (21), 13 (1); first haemal arch 9 (16), 10 (6). Dorsal 90 to 98; anal 72 to 80.

Citharichthys xanthostigmus Gilbert. Sand dab.

Individuals examined: 3 from Huntington Beach, 9 from Dana Pt., and 3 from Cedros Island, Lower California. Total vertebrae 36 (2), 37 (5), 38 (8); first haemal spine 12 (15); first haemal arch 9 (15). Dorsal 81 to 88; anal 63 to 67.

Citharichthys stigmaeus Jordan and Gilbert. Sand dab.

Individuals examined: 13 from the vicinity of San Pedro and 1 from north of Drakes Bay, exact locality unknown. Total vertebrae 37 (6), 38 (8); first haemal spine 11 (14); first haemal arch 9 (13), 10 (1). Dorsal 83 to 92; anal 67 to 72.

Lyopsetta exilis (Jordan and Gilbert). Slender Sole.

The first haemal spine and first 4 neural spines are heavy. The rest of the haemal and neural spines are thin and weak. The first haemal arch and the first haemal spine are on the same vertebra.

Individuals examined: 10 from between Eureka and Crescent City and 10 from Santa Cruz Island. Total vertebrae 44 (3), 45 (8), 46 (8), 47 (1); first haemal spine 13 (20); first haemal arch 13 (20). Dorsal 77 to 85; anal 59 to 65.

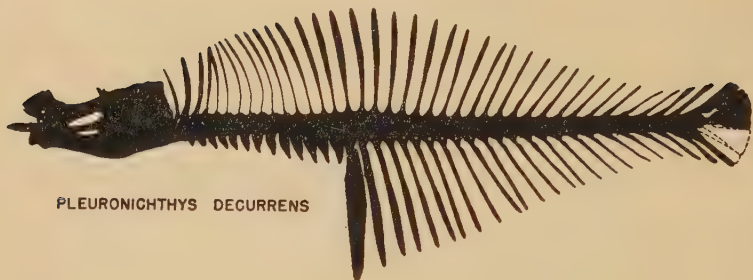
Eopsetta jordani (Lockington). Petrale Sole (not illustrated).

Individuals examined: 2 from San Pedro fish markets, 1 from Long Beach and 11 from between Eureka and Crescent City. Total vertebrae 42 (3), 43 (11); first haemal spine 12 (14); first haemal arch 9 (1), 10 (7), 11 (5), 12 (1). Dorsal 89 to 95; anal 70 to 75.

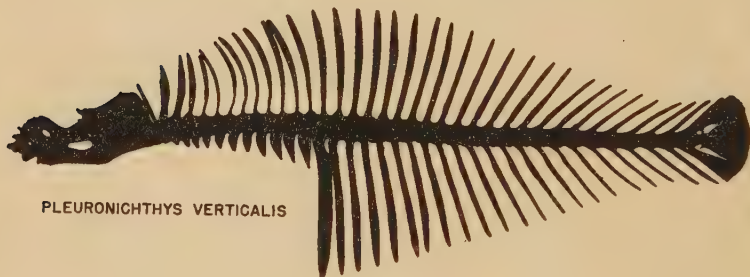
Hypsopsetta guttulata (Girard). Diamond Turbot.

The first haemal spine and the first haemal arch are on the same vertebra. The parapophyses preceding the first haemal spine are long and pointed. The haemal and neural spines, especially the first haemal spine, are long, strong and heavy.

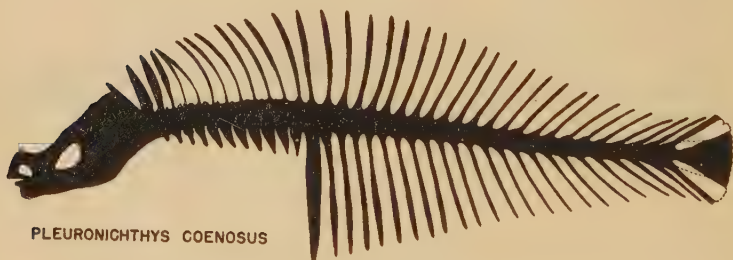
Individuals examined: 12 from the vicinity of San Pedro and Newport Beach. Total vertebrae 35 (10), 36 (2); first haemal spine 13 (12); first haemal arch 13 (12). Dorsal 66 to 75; anal 48 to 54.



PLEURONICHTHYS DECURRENS



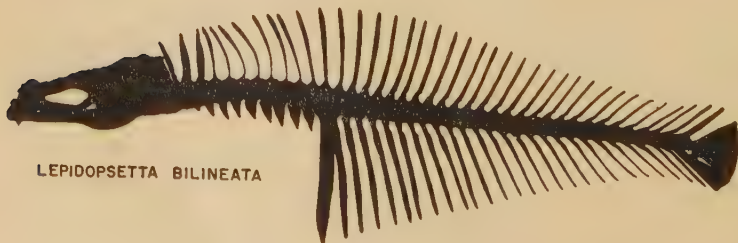
PLEURONICHTHYS VERTICALIS



PLEURONICHTHYS COENOSUS



PAROPHRYS VETULUS



LEPIDOPSETTA BILINEATA

Pleuronichthys decurrens Jordan and Gilbert. Curfin Turbot.

The supraoccipital crest is very small. The haemal and neural spines are pierced by a small hole near their bases. The first haemal spine is about twice as thick as the second. The first haemal arch and the first haemal spine are on the same vertebra.

Individuals examined: 3 from between Eureka and Crescent City. Total vertebrae 39 (1), 40 (2); first haemal spine 15 (2), 16 (1); first haemal arch 15 (2), 16 (1). Dorsal 70 to 75; anal 47 to 50.

Pleuronichthys verticalis Jordan and Gilbert. Sharpridge Turbot.

The supraoccipital crest is very small. The parapophyses preceding the first haemal spine are long and pointed. The first haemal arch and the first haemal spine are on the same vertebra.

Individuals examined: 17 from various points from Newport Beach to Gaviota. Total vertebrae 36 (8), 37 (9); first haemal spine 14 (17); first haemal arch 14 (17). Dorsal 65 to 72; anal 44 to 49.

Pleuronichthys coenosus Girard. C-O Turbot.

The supraoccipital crest is very small. The haemal spines are pierced by a small hole near their bases. The first haemal spine is much heavier than the second. The first haemal spine and the first haemal arch are on the same vertebra.

Individuals examined: 10 from Santa Barbara and Gaviota. Total vertebrae 37 (2), 38 (7), 39 (1); first haemal spine 14 (10); first haemal arch 14 (10). Dorsal 68 to 76; anal 49 to 53.

Pleuronichthys ritteri Starks and Morris. Spotted Turbot (not illustrated).

The supraoccipital crest is very small. The parapophyses preceding the first haemal spine are short and stubby. The first haemal arch and the first haemal spine are on the same vertebra.

Individuals examined: 7 from San Diego Bay. Total vertebrae 35 (6), 36 (1); first haemal spine 13 (6), 14 (1); first haemal arch 13 (6), 14 (1). Dorsal 61 to 69; anal 45 to 49.

Parophrys vetulus Girard. English Sole.

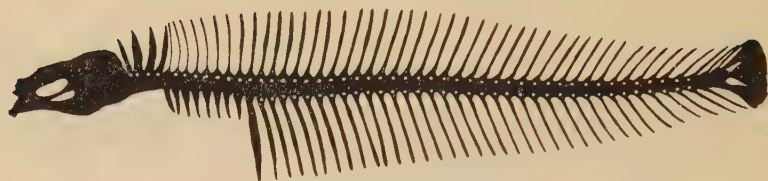
The first two haemal spines are widened and enlarged antero-posteriorly so that the first is partly enclosed by the second. The first haemal arch and the first haemal spine are on the same vertebra.

Individuals examined: 7 from off Pt. Dume and 11 from between Eureka and Crescent City. Total vertebrae 42 (5), 43 (2), 44 (8), 45 (3); first haemal spine 12 (18); first haemal arch 12 (18). The northern specimens were the ones with the total vertebra counts of 44 and 45. Dorsal 71 to 86; anal 54 to 68.

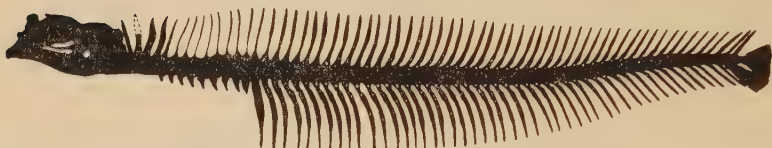
Lepidopsetta bilineata (Ayres). Broadfin Sole.

The very heavy first haemal spine originates in close juxtaposition with the base of the second spine. The first haemal spine and the first haemal arch are on the same vertebra.

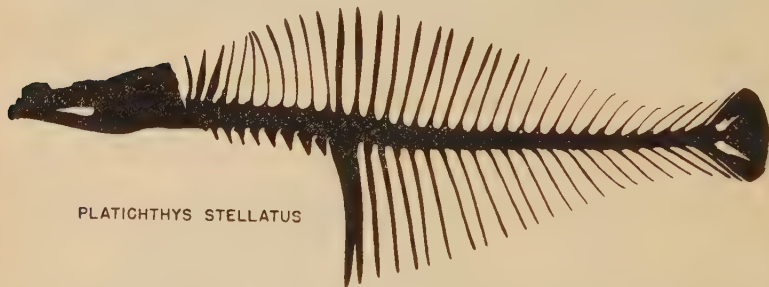
Individuals examined: 2 from between Eureka and Crescent City. Total vertebrae 40 (2); first haemal spine 12 (2); first haemal arch 12 (2). Dorsal 68 to 81; anal 52 to 63.



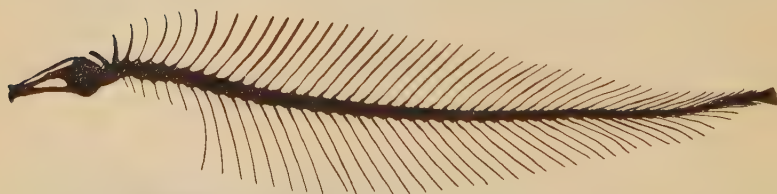
MICROSTOMUS PACIFICUS



GLYPTOCEPHALUS ZACHIRUS



PLATICHTHYS STELLATUS



SYMPHURUS ATRICAUDUS



STEREOLEPIS GIGAS



PARALABRAX CLATHRATUS

Microstomus pacificus (Lockington). Dover Sole.

The haemapophyses are very long and narrow. The first haemal spine is heavy. The haemal and neural spines are nearly all of the same length, showing only a slightly diminishing length toward the tail. Almost every haemal and neural spine is perforated at the base by a small hole.

Individuals examined: 11 from between Eureka and Crescent City. Total vertebrae 51 (4), 52 (4), 53 (3); first haemal spine 13 (9), 14 (2); first haemal arch 6 (8), 7 (3). Dorsal 94 to 106; anal 80 to 88.

Glyptocephalus zachirus Lockington. Rex Sole.

The first haemal arch and the first haemal spine are on the same vertebra. All haemal and neural spines are of nearly the same length, the skeleton tapering very gradually toward the tail. Posteriorly, most of the haemal and neural spines are perforated near their bases by a small hole.

Individuals examined: 2 from San Pedro fish markets. Total vertebrae 64 (2); first haemal spine 14 (1), 15 (1); first haemal arch 14 (1), 15 (1). Dorsal 94 to 107; anal 79 to 89.

Platichthys stellatus (Pallas). Starry Flounder.

The first haemal arch and the first haemal spine are on the same vertebra. The first haemal spine is in close juxtaposition with the second haemal spine.

Individuals examined: 6 from between Eureka and Crescent City. Total vertebrae 36 (5), 37 (1); first haemal spine 12 (6); first haemal arch 12 (6). Dorsal 56 to 62; anal 40 to 46.

Symphurus atricaudus (Jordan and Gilbert). Tongue Sole.

The first haemal arch and the first haemal spine are on the same vertebra. The haemal spines on vertebrae 4 to 9 are very short. The haemal and neural spines from 10 on are long and thin, gradually shortening and lying close to the vertebral column, giving, with the very small urostyle, a distinctive, tapered appearance to the whole skeleton.

Individuals examined: 7 from the vicinity of San Pedro, 1 from Santa Catalina Island, 2 from off Santa Barbara and 1 from Lower California. Total vertebrae 50 (2), 51 (6), 52 (3); first haemal spine 4 (11); first haemal arch 4 (11). Dorsal 101 to 106; anal 83 to 90.

Stereolepis gigas Ayres. Black Sea Bass.

The supraoccipital is moderately high but short, with the top edge in line with a continuation of the frontal bones of the skull.

Individuals examined: 1 from Chester Rocks, Lower California. Total vertebrae 26; first haemal spine 13; first haemal arch 9. Dorsal XI, 10; anal III, 8.

Paralabrax clathratus (Girard). Kelp Bass.

The supraoccipital crest is almost absent, represented only by a small rounded fin at the back of the skull.

Individuals examined: 6 from San Pedro fresh fish markets, 3 from Newport Bay and 1 from Santa Cruz Island. Total vertebrae 24 (10); first haemal spine 11 (10); first haemal arch 8 (8), 9 (2). Dorsal X, 13; anal III, 7.

Paralabrax nebulifer (Girard). Sand Bass (not illustrated).

Practically identical with *P. clathratus*.

Individuals examined: 11 from San Pedro fish markets, 4 from off the town of San Clemente and 1 from Turtle Bay, Lower California. Total vertebrae 24 (16); first haemal spine 11 (16); first haemal arch 7 (1), 8 (14), 9 (1). Dorsal X, 14 to 15; anal III, 7.

Paralabrax maculato-fasciatus (Steindachner). Spotted Sand Bass (not illustrated).

Practically identical with *P. clathratus*.

Individuals examined: 3 from Mission Bay, San Diego and 9 from Magdalena Bay, Lower California. Total vertebrae 24 (12); first haemal spine 11 (12); first haemal arch 7 (4), 8 (8). Dorsal X, 13 to 14; anal III, 7 to 8.



LEURESTHES TENUIS



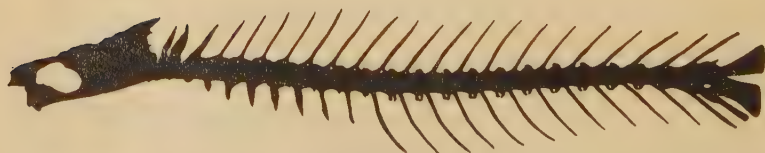
ATHERINOPS AFFINIS



MUGIL CEPHALUS



SPHYRAENA ARGENTEA



POLYDACTYLUS APPROXIMANS



EUCINOSTOMUS ARGENTEUS

Leuresthes tenuis (Ayres). Grunion.

The haemal and neural spines are very short, shorter than in *Atherinops affinis*. A haemal funnel is present. For a description of this structure see page 7 and fig. 1.

Individuals examined: 11 from vicinity of San Pedro. Total vertebrae 48 (4), 49 (7); first haemal spine 37 (4), 38 (4), 39 (2), 40 (1); first haemal arch 23 (2), 24 (5), 25 (4). Dorsal V-I, 9; anal I, 22.

Atherinopsis californiensis Girard. Jack Smelt (not illustrated).

There is a haemal funnel. For a description of this structure see page 7 and fig. 1.

Individuals examined: 10 from San Pedro fish markets, 1 from off Malibu and 3 from off Gaviota. Total vertebrae 51 (11), 52 (3); first haemal spine 40 (7), 41 (6), 42 (1); first haemal arch 23 (1), 24 (5), 25 (8). Dorsal IX-I, 12; anal I, 23.

Atherinops affinis (Ayres). Top Smelt.

The haemal and neural spines are longer than in *Leuresthes tenuis*. A haemal funnel is present. For a description of this structure see page 7 and fig. 1.

Individuals examined: 13 from San Pedro fish markets, 6 from Cabrillo Beach, and 7 from Santa Catalina Island. Total vertebrae 46 (4), 47 (3), 48 (14), 49 (4), 50 (1); first haemal spine 34 (4), 35 (12), 36 (8), 37 (1), 38 (1); first haemal arch 22 (3), 23 (18), 24 (5). Dorsal V to VII-I, 9 to 12; anal I, 22 to 24.

Mugil cephalus Linnaeus. Mullet.

The skull is elongated and the supraoccipital very low and extended backward to the midpoint of the atlas. The epiotics are produced backward into thin "feathers" ending just before the junction of second and third vertebra. The first haemal spine is bent backward parallel to the vertebral column and is much shorter than the second spine.

Individuals examined: 16 from Lower California waters. Total vertebrae 24 (16); first haemal spine 12 (16); first haemal arch 9 (1), 10 (15). Dorsal IV to V-I, 8; anal III, 7 to 8.

Sphyræna argentea Girard. Barracuda.

The skull is exceedingly elongated. The supraoccipital is extended backward into a low thin brushlike plate ending at the juncture of the second vertebra and the atlas. The epiotics are extended backward into long brushes ending at the juncture of the third and fourth vertebrae. The vertebral centrums are elongated and the haemal and neural spines are very short and weak. The first haemal arch and the first haemal spine are on the same vertebra.

Individuals examined: 10 from Santa Barbara, San Pedro, Oceanside and San Clemente Island. Total vertebrae 24 (10); first haemal spine 14 (10); first haemal arch 14 (10). Dorsal V-I, 8 to 9; anal I to II, 8 to 9.

Polydactylus approximans (Lay and Bennett). Threadfin.

Not native to these waters, but nevertheless occasionally found here perhaps released by tuna clippers which empty their live bait tanks locally after returning from southern trips.

The eye is placed well forward in the skull and the supraoccipital is low, ending in a sharp point over the atlas. The spines are thin and the haemapophyses long.

Individuals examined: 6 taken in the vicinity of San Pedro and Long Beach. Total vertebrae 24 (6); first haemal spine 11 (6); first haemal arch 6 (6). Dorsal VIII-I, 12; anal III, 13 to 14.

Eucinostomus argenteus Baird and Girard. Mojarra.

The supraoccipital is high and pointed, ending over the atlas. The first haemal spine is thin, short and weak, originating from a long strong pair of fused haemapophyses. The second interhaemal spine (not shown in the illustration) is enlarged and hollowed out anteriorly.

Individuals examined: 16 from Turtle Bay, Lower California. Total vertebrae 24 (16); first haemal spine 11 (16); first haemal arch 6 (1), 7 (15). Dorsal IX, 10; anal II, 7.



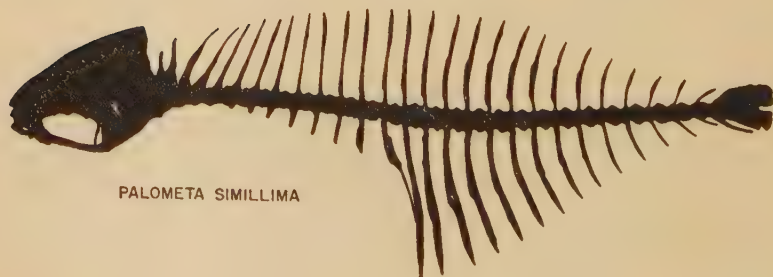
SERIOLA DORSALIS



NAUCRATES DUCTOR



TRACHURUS SYMMETRICUS

CHLOROSCOMBRUS
ORQUETA

PALOMETA SIMILLIMA



REMORA REMORA

Seriola dorsalis (Gill). Yellowtail.

Individuals examined: 1 from San Pedro fish markets and 1 from Pt. San Juanico, Lower California. Total vertebrae 25 (2); first haemal spine 12 (2); first haemal arch 10 (2). Dorsal V to VII-I, 35 to 39; anal II-I, 19 to 21.

Naucrates ductor (Linnaeus). Pilotfish.

The low supraoccipital extends from the frontal back to the junction of the atlas and the second vertebra. The skull is very thin and depressed over the orbit. (This depression is not visible in the illustration because it is obscured by the supraoccipital and epiotic crests.)

Individuals examined: 1 taken off Newport Beach and 4 from Morgan Bank off Lower California. Total vertebrae 25 (5); first haemal spine 11 (5); first haemal arch 9 (5). Dorsal III to V-I, 25 to 27; anal II-I, 16 to 17.

Trachurus symmetricus (Ayres). Jack Mackerel.

The haemal and neural zygapophyses are quite heavy. The haemal and neural spines on the last 4 vertebrae lie flat against the centrums.

Individuals examined: 560 from Southern California and 256 from Monterey Bay. Total vertebrae 23 (1), 24 (813), 25 (2); first haemal spine 10 (1), 11 (812), 12 (3); first haemal arch 8 (1), 9 (745), 10 (64). Dorsal VIII-I, 29 to 38; anal II-I, 24 to 33.

Chloroscombrus orqueta Jordan and Gilbert. Yellowtail Jack.

The haemal and neural spines are widely spaced. The first haemal spine extends straight out from the centrum and curves slightly forward. The haemal apophyses in front of the first haemal spine are long, sharp pointed, and expanded fore and aft the full length of the centrum and perforated with a large hole.

Individuals examined: 1 from San Pedro fish markets and 2 from San Quintin, Lower California. Total vertebrae 24 (3); first haemal spine 11 (3); first haemal arch 8 (3). Dorsal VI to VII-I-I, 26 to 30; anal II-I, 27 to 30.

Palometa simillima (Ayres). Pompano.

The supraoccipital is high and pointed. The haemal and neural spines are very long and slender, the first shorter than the second with the distal half much reduced and curving back, almost touching the second.

Individuals examined: 1 from San Pedro fish markets, 1 from Malibu Point, 23 from Oceanside and 14 from San Quintin, Lower California. Total vertebrae 29 (1), 30 (35), 31 (3); first haemal spine 13 (39); first haemal arch 8 (31), 9 (8). Dorsal III-46; anal III-40.

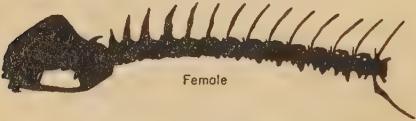
Remora remora (Linnaeus). Remora.

The skull is flattened and widened with the upper surface concave. The neural and haemal spines are all short. The parapophyses from the skull to the first haemal spine extend laterally far out from the centrums reaching their greatest length on about the fifth vertebra, and from there on gradually shortening and turning downward. The first haemal arch and the first haemal spine are on the same vertebra. The spines of the first dorsal fin are modified into the plates in the sucking disk.

Individuals examined: 4 from the vicinity of San Pedro and 1 from Costa Rica. Total vertebrae 27 (5); first haemal spine 12 (1), 13 (4); first haemal arch 12 (1), 13 (4). Dorsal XVII to XVIII-22 to 26; anal 22 to 25.



Male



Female

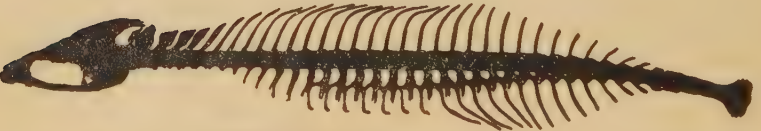
CORYPHAENA HIPPIURUS



SCOMBEROMORUS SIERRA



SARDA LINEOLATA



KATSUWONUS PELAMIS



AUXIS THAZARD



THUNNUS GERMONTI

PLATE X

Coryphaena hippurus Linnaeus. Dolphin.

The supraoccipital crest is very heavy and high. In the male it rises abruptly reaching a peak anterior to the orbit. In the female it slants upward to a peak over the orbit. The first haemal arch and the first haemal spine are on the same vertebra.

Individuals examined: 6 from Mexican waters. Total vertebrae 31 (6); first haemal spine 14 (6); first haemal arch 14 (6). Dorsal 55 to 65; anal 25 to 30.

Pneumatophorus diego (Ayres). Pacific Mackerel. (See fig. 2.)

Individuals examined: over 1000. Total vertebrae 31, very rarely 30 or 32; first haemal spine 15, about one in 100 on 14 or 16; first haemal arch 11, about one in 30 on 10 or 12. Dorsal IX-I, 9 to 13-IV to VI; anal I-I, 9 to 11-IV to VI.

Scomberomorus sierra Jordan and Starks. Sierra.

Posterior extension of line drawn along anterior midline of skull falls below upper edge of supraoccipital crest.

Individuals examined: 17 from Lower California waters. Total vertebrae 47 (1), 48 (13), 49 (3); first haemal spine 21 (16), 22 (1); first haemal arch 12 (14), 13 (2), 14 (1). Dorsal XVI to XVIII-15 to 18-VIII to IX; anal II, 15 to 18-VIII to IX.

Scomberomorus concolor (Lockington). Monterey Spanish Mackerel (not illustrated).

Posterior extension of line drawn along anterior midline of skull coincides with, or is above, upper edge of supraoccipital crest.

Individuals examined: 1 from Newport Bay and 1 from Portuguese Bend. Total vertebrae 47 (1), 48 (1); first haemal spine 20 (1), 21 (1); first haemal arch 12 (1), 13 (1). Dorsal XVI to XVII-16 to 18-VIII; anal II, 16 to 20-VII to VIII.

Sarda lineolata (Girard). Bonito.

Individuals examined: 3 from San Pedro fish markets, 4 from off Oceanside, 1 from Anacapa Island and 2 from the vicinity of San Pedro. Total vertebrae 44 (1), 45 (8), 46 (1); first sudden increase in the length of the haemal spines 22 (1), 24 (9); first haemal arch 12 (3), 13 (5), 14 (2). Dorsal XVIII-I, 12 to 14-VI to VIII; anal II, 10 to 11-VI to VII.

Katsuwonus pelamis (Linnaeus). Skipjack.

The haemapophyses are very complicated, as shown in the illustration. The haemal arch is inordinately large and is carried a short distance out from the vertebral column by fused haemapophyses. Haemal zygapophyses are very long and slender, extending far out from the centrums and forming a semicircle around the haemal artery.

Individuals examined: 10 brought in by a tuna clipper from southern waters. Total vertebrae 41 (10); first haemal spine 21 (8), 22 (2); first haemal arch 12 (9), 13? (1) (skeleton damaged). Dorsal XV-12-VIII; anal II, 12-VII.

Auxis thazard (Lacépède). Frigate Mackerel.

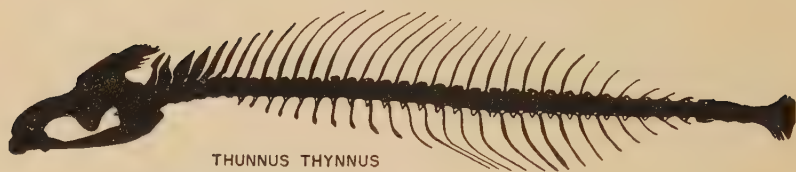
The parapophyses on each vertebra are fused for their entire length. The haemapophyses on each vertebra are fused from the centrum to the haemal arch. (See fig. 18.) The first haemal spine and the first haemal arch are on the same vertebra.

Individuals examined: 1 from Sebastian Viscaïno Bay and 2 from Espiritu Santo Island, Lower California. Total vertebrae 39 (3); first haemal spine 21 (3); first haemal arch 21 (3). Dorsal X-12-VIII; anal 13-VII.

Thunnus germo (Lacépède). Albacore.

The posterior margin of the basioccipital is angular. The alisphenoids extend about half way into the interorbital opening. The first haemal arch is bent forward nearly parallel to the vertebral column and the succeeding arches gradually become perpendicular to the column. See Godsil and Byers (1944) for a detailed description of the osteology.

Individuals examined: 1 from Japan, 5 from off the Columbia River and 5 from California waters. Total vertebrae 39 (11); first sudden increase in the length of the haemal spines 19 (11); first haemal arch 10 (11). Dorsal XIII to XIV-15 to 16-VII to VIII; anal 14 to 15-VII to VIII.



THUNNUS THYNNUS



NEOTHUNNUS MACROPTERUS



XENISTIUS CALIFORNIENSIS



ANISOTREMUS DAVIDSONII



CHEILO TREMA SATURNUM



RONCADOR STEARNSII

Thunnus thynnus (Linnaeus). Bluefin Tuna.

The posterior margin of the basioccipital is angular. The alisphenoids extend well into the interorbital opening and more than half way to its base. There is a pronounced notch in the frontals just anterior to the supraoccipital. (See fig. 17.) See Godsil and Byers (1944) for a detailed description of the osteology.

Individuals examined: 15 from Southern California waters. Total vertebrae 39 (15); first sudden increase in the length of the haemal spines 19 (15); first haemal arch 9 (1), 10 (13), 11 (1). Dorsal XII to XIV-15-VII; anal 14 to 15-VII to VIII.

Neothunnus macropterus (Temminck and Schlegel). Yellowfin Tuna.

The posterior margin of the basioccipital is rounded. The alisphenoids extend less than half way into the interorbital opening. (See fig. 17.) See Godsil and Byers (1944) for a detailed description of the osteology.

Individuals examined: 8 from Uncle Sam Bank, 1 from Morgan Bank and 3 brought in by tuna clippers from unknown localities. Total vertebrae 39 (12); first sudden increase in the length of the haemal spines 19 (12); first haemal arch 10 (4), 11 (7), 12 (1). Dorsal XII to XIV-14 to 16-VIII to IX; anal 14 to 15-VII to VIII.

Xenistius californiensis (Steindachner). Big-eye Bass.

The supraoccipital crest does not extend beyond the junction of the skull and the atlas. The first three haemal spines are bent backward and almost touch at the tips.

Individuals examined: 1 from south of San Diego, 1 from Cedros Island, Lower California, 2 from Santa Maria Bay, Lower California, 1 from the vicinity of Ocean-side and 8 from the vicinity of San Pedro. Total vertebrae 26 (13); first haemal spine 11 (13); first haemal arch 8 (12), 9 (1). Dorsal IX-I to II, 12 to 14; anal III, 10 to 12.

Anisotremus davidsonii (Steindachner). Sargo.

The supraoccipital crest is very high and sharply pointed. The neural spines are long and heavy. The first and second haemal spines are curved backward so that their ends are in close juxtaposition with the following spine. The basisphenoid extends forward onto the parasphenoid and projects up into the orbital opening.

Individuals examined: 7 from Ballenas Bay, Lower California, 1 from Newport Beach and 4 from Redondo Beach. Total vertebrae 26 (12); first haemal spine 11 (12); first haemal arch 8 (12). Dorsal XI to XII, 15 to 16; anal III, 10 to 11.

Cheilotrema saturnum (Girard). Black Croaker.

The basisphenoid extends up to the midline of the orbital opening. The supraoccipital crest is high and pointed, extending back over the second vertebra. The neural spines are long and strong.

Individuals examined: 3 from the vicinity of San Pedro. Total vertebrae 24 (1), 25 (2); first haemal spine 11 (3); first haemal arch 7 (2), 8 (1). Dorsal IX-I to II, 26 to 27; anal II, 7 to 9.

Roncador stearnsii (Steindachner). Spotfin Croaker.

The ventral surfaces of the second to the fifth vertebrae are heavily ridged. The supraoccipital crest is high. The haemal and neural zygapophyses are heavy and pronounced.

Individuals examined: 20 from the vicinity of San Pedro and Newport Beach. Total vertebrae 25 (20); first haemal spine 11 (20); first haemal arch 7 (20). Dorsal X-I, 21 to 24; anal II, 7 to 9.



GENYONEMUS LINEATUS



UMBRINA RONCADOR



MENTICIRRHUS UNDULATUS



SERIPHUS POLITUS



CYNOSCION NOBILIS



CYNOSCION PARVIPINNIS

Genyonemus lineatus (Ayres). Kingfish.

The first haemal arch is difficult to find because the canal is bridged merely by slender, hairlike processes of the haemapophyses. All spines except the first two or three neural spines are weak. The haemapophyses are long. There is a large bulge in the prootic region over the auditory labyrinth.

Individuals examined: 12 from San Pedro fish markets, 1 from Newport Beach and 2 from San Quintin, Lower California. Total vertebrae 26 (15); first haemal spine 12 (14), 13 (1); first haemal arch 7 (11), 8 (4). Dorsal XII to XV-I, 18 to 24; anal II, 10 to 12.

Umbrina roncadore Jordan and Gilbert. Yellowfin Croaker.

The supraoccipital crest is high and pointed. The basisphenoid is enlarged, extending forward on the parasphenoid and upward to nearly the midpoint of the orbital opening.

Individuals examined: 17 from the vicinity of San Pedro, Long Beach and Newport Beach. Total vertebrae 24 (1), 25 (16); first haemal spine 11 (17); first haemal arch 7 (12), 8 (4), 9 (1). Dorsal X-I, 25 to 28; anal II, 6 to 7.

Menticirrhus undulatus (Girard). California Corbina.

The supraoccipital crest is short and of medium height, not extending to the junction of the atlas and the second vertebrae. The neural and haemal spines are thin and weak.

Individuals examined: 1 from Malibu, 1 from San Pedro fish markets and 11 from Terminal Island. Total vertebrae 25 (13); first haemal spine 11 (13); first haemal arch 7 (1), 8 (11), 9 (1). Dorsal X to XI-I to II, 23 to 27; anal I to II, 8 to 9.

Seriophilus politus Ayres. Queenfish.

The supraoccipital crest is of medium height ending at the base of the skull. There is a large bulge in the prootic region over the auditory labyrinth.

Individuals examined: 8 from Newport Beach, 5 from San Pedro fish markets and 3 from San Quintin, Lower California. Total vertebrae 25 (16); first haemal spine 11 (16); first haemal arch 7 (15), 8 (1). Dorsal VIII-I, 20; anal II, 21 to 22.

Cynoscion nobilis (Ayres). White Sea Bass.

The skull is slightly elongated and the haemapophyses are long. The first 6 or 7 neural spines are long and heavy.

Individuals examined: 14 from the vicinity of San Pedro. Total vertebrae 25 (14); first haemal spine 13 (4), 14 (10); first haemal arch 9 (2), 10 (9), 11 (2), 12 (1). Dorsal IX to X-I, 19 to 23; anal II, 8 to 10.

Cynoscion parvipinnis Ayres. Shortfin Sea Bass.

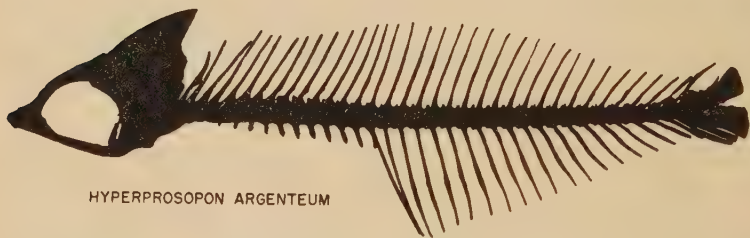
The skull is slightly elongated. The supraoccipital crest is low and extends back to the midpoint of the atlas. The neural spines are short, weak and thin posteriorly, heavy anteriorly.

Individuals examined: 1 from Ballenas Bay and 1 from Magdalena Bay, Lower California. Total vertebrae 23 (2); first haemal spine 12 (1), 13 (1); first haemal arch 11 (2). Dorsal X-I, 22 to 23; anal II, 9 to 10.

To verify this low vertebra count, Dr. W. I. Follett, of the California Academy of Sciences, was asked to dissect the material on hand there and he sent in these additional data: 3 from Magdalena Bay, Lower California, 2 from Guaymas, Sonora, and 1 from San Diego, California. Total vertebrae 23 (6); first haemal spine 14 (6); first haemal arch 10 (2), 11 (4).



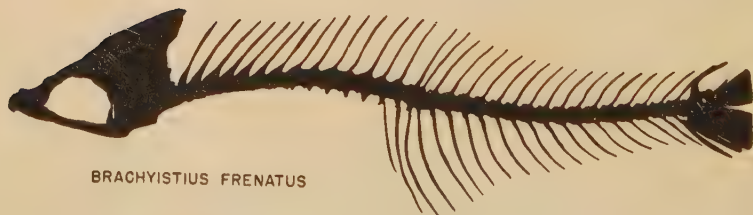
CAULOLATILUS PRINCEPS



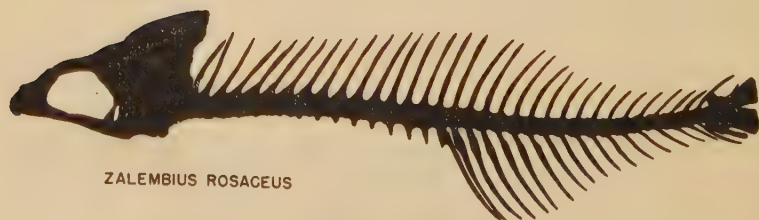
HYPERPROSOPON ARGENTEUM



CYMATOGASTER AGGREGATA



BRACHYISTIUS FRENATUS



ZALEMBEUS ROSACEUS

Caulolatilus princeps (Jenyns). Ocean Whitefish.

The supraoccipital crest is low and short. The first haemal spine is frequently preceded by a very large haemal arch from which proceeds a very thin hairlike bone.

Individuals examined: 7 from San Pedro fish markets and 6 from Cedros Island, Lower California. Total vertebrae 27 (13); first haemal spine 13 (13); first haemal arch 11 (1), 12 (9), 13 (3). Dorsal IX, 24 to 26; anal II, 23 to 24.

Hyperprosopon argenteum Gibbons. Walleyed Perch.

The orbit is very large, its greatest vertical diameter $2\frac{1}{4}$ to $2\frac{1}{2}$ times into length of skull, measured on a straight line from the vomer to the atlas. The first haemal spine and the first haemal arch are on the same vertebra.

Individuals examined: 5 from San Pedro fish markets, 5 from Santa Catalina Island and 1 from vicinity of San Pedro. Total vertebrae 34 (3), 35 (5), 36 (1), 37 (1), 38 (1); first haemal spine 14 (7), 15 (4); first haemal arch 14 (7), 15 (4). Dorsal IX, 27; anal III, 32 to 34.

Cymatogaster aggregata Gibbons. Shiner Perch.

The first haemal spine and the first haemal arch are nearly always on the same vertebra.

Individuals examined: 1 from San Pedro fish markets and 9 from Santa Catalina Island. Total vertebrae 34 (1), 35 (4), 36 (4), 38 (1); first haemal spine 15 (4), 16 (6); first haemal arch 14 (1), 15 (3), 16 (6). Dorsal IX, 20; anal III, 23.

Brachyistius frenatus Gill. Kelp Perch.

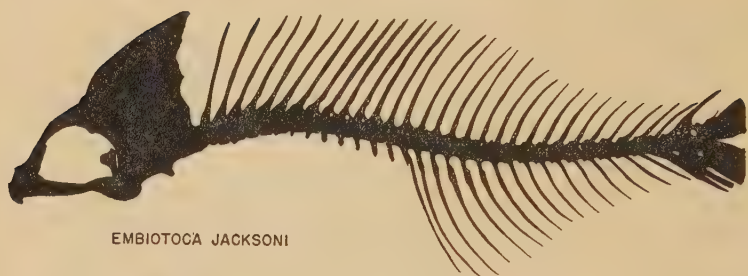
The first haemal spine and the first haemal arch are nearly always on the same vertebra.

Individuals examined: 26 from the vicinity of San Pedro. Total vertebrae 32 (1), 33 (7), 34 (14), 35 (4); first haemal spine 12 (2), 13 (20), 14 (4); first haemal arch 12 (3), 13 (18), 14 (5). Dorsal VII to IX, 13 to 15; anal III to IV, 20 to 25.

Zalemmbius rosaceus (Jordan and Gilbert). Pink Perch.

The first haemal spine and the first haemal arch are nearly always on the same vertebra.

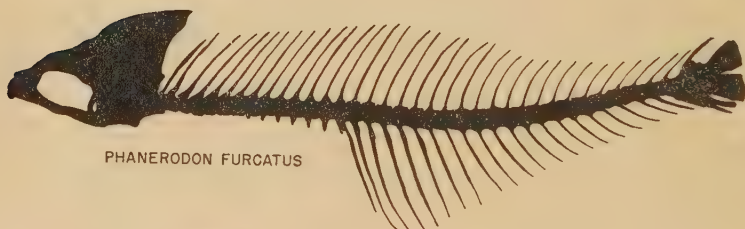
Individuals examined: 14 from the vicinity of San Pedro. Total vertebrae 33 (3), 34 (7), 35 (4); first haemal spine 15 (2), 16 (12); first haemal arch 15 (3), 16 (11). Dorsal IX to XI, 17 to 19; anal III, 18 to 20.



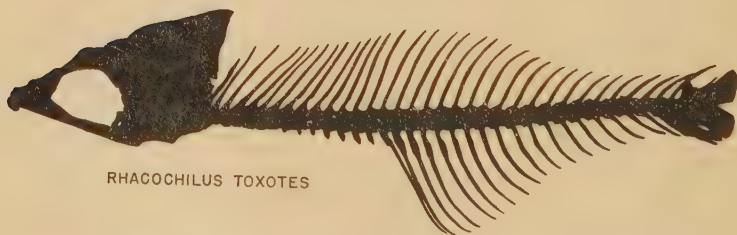
EMBIOTOCA JACKSONI



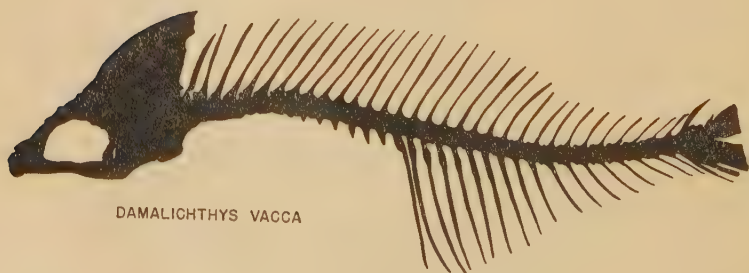
HYPSURUS CARYI



PHANERODON FURCATUS



RHACOCHELUS TOXOTES



DAMALICHTHYS VACCA

Embiotoca jacksoni Agassiz. Black Perch.

The first haemal spine and the first haemal arch are on the same vertebra.

Individuals examined: 19 from Newport Beach, Santa Catalina Island, San Pedro and Santa Barbara. Total vertebrae 33 (2), 34 (12), 35 (5); first haemal spine 15 (3), 16 (16); first haemal arch 15 (3), 16 (16). Dorsal IX to X, 20; anal III, 25.

Hypsurus caryi (Agassiz) Rainbow Perch.

The first haemal spine and the first haemal arch are nearly always on the same vertebra. The supraoccipital crest does not extend beyond the junction of the skull and atlas.

Individuals examined: 11 from the vicinity of San Pedro. Total vertebrae 36 (4), 37 (4), 38 (3); first haemal spine 16 (1), 18 (7), 19 (3); first haemal arch 16 (1), 18 (8), 19 (2). Dorsal X to XI, 20 to 23; anal III, 20 to 24.

Phanerodon furcatus Girard. Pacific White Perch.

The first haemal spine and the first haemal arch are nearly always on the same vertebra.

Individuals examined: 6 from San Pedro fish markets, 1 from Newport Bay and 10 from the vicinity of San Pedro. Total vertebrae 37 (6), 38 (5), 39 (5), 41 (1); first haemal spine 14 (3), 15 (13), 16 (1); first haemal arch 14 (4), 15 (12), 16 (1). Dorsal X to XI, 22 to 26; anal III, 30 to 33.

Rhacochilus toxotes Agassiz. Rubberlip Perch.

The first haemal spine and the first haemal arch are on the same vertebra.

Individuals examined: 11 from the vicinity of San Pedro. Total vertebrae 35 (7), 36 (3), 37 (1); first haemal spine 15 (10), 16 (1); first haemal arch 15 (10), 16 (1). Dorsal IX to X, 20 to 25; anal III, 28 to 30.

Damalichthys vacca Girard. Pile Perch.

The first haemal spine and the first haemal arch are nearly always on the same vertebra. The atlas is partially fused with the skull but may be distinguished by the presence of a neural spine. There are two large downward projecting knobs in the prootic region.

Individuals examined: 10 from the vicinity of San Pedro. Total vertebrae 34 (1), 35 (5), 36 (2), 37 (1), 39 (1); first haemal spine 14 (1), 15 (7), 16 (2); first haemal arch 14 (2), 15 (6), 16 (2). Dorsal X to XI, 22 to 23; anal III, 27 to 30.

Micrometrus minimus (Gibbons). Dwarf Perch (not illustrated).

The first haemal spine and the first haemal arch are on the same vertebra.

Individuals examined: 5 from near Pt. Fermin and 11 from Pt. San Telmo, Lower California. Total vertebrae 31 (1), 32 (5), 33 (4), 34 (3), 35 (2), 36 (1); first haemal spine 13 (1), 14 (3), 15 (10), 16 (2); first haemal arch 13 (1), 14 (3), 15 (10), 16 (2). Dorsal IX to X, 13 to 16; anal III, 13 to 23.



CHROMIS PUNCTIPINNIS



HYPSYPOPS RUBICUNDA



PIMELOMETOPON PULCHRUM



HALICHOERES SEMICINCTUS



OXYJULIS CALIFORNICUS

Chromis punctipinnis (Cooper). Blacksmith.

The skull is high and the supraoccipital crest very high, the point slightly rounded.

Individuals examined: 7 from San Clemente Island and 3 from San Pedro fish markets. Total vertebrae 26 (10); first haemal spine 12 (10); first haemal arch 10 (8), 11 (2). Dorsal XIII, 11 to 13; anal II, 11 to 12.

Hypsypops rubicunda (Girard). Garibaldi.

The first haemal spine and the first haemal arch are nearly always on the same vertebra. The supraoccipital crest is very high, rising abruptly at a steep angle from a point over the frontals. All spines are long and heavy. The first three haemal spines are enlarged, hollowed out and in close juxtaposition with each other.

Individuals examined: 6 from the vicinity of Newport Beach, 1 from Portuguese Bend, 5 from Santa Catalina Island and 4 from Ensenada, Lower California. Total vertebrae 26 (16); first haemal spine 12 (16); first haemal arch 11 (1), 12 (15). Dorsal XIII, 16; anal II, 13 to 15.

Pimelometopon pulchrum (Ayres). Sheepshead.

The supraoccipital crest is low and rounded. The parapophyses, haemapophyses and zygapophyses of the abdominal vertebrae are long and strong. The haemapophyses on the vertebra carrying the first haemal spine are very long and the first bridging forms a small haemal arch. A very much larger arch is formed by a second bridging about half way down on the haemapophyses. The first haemal spine originates from the center of this second bridging, the haemapophyses continuing on to end in sharp points.

Individuals examined: 9 from San Pedro fish markets and 2 from off the town of San Clemente. Total vertebrae 28 (11); first haemal spine 12 (11); first haemal arch 9 (5), 10 (4), 11 (2). Dorsal XII, 10; anal III, 10 to 12.

Halichoeres semicinctus (Ayres). Rock-wrasse.

On the vertebra where the first haemal spine occurs, the haemapophyses join to form a small haemal arch and then extend outward and downward before again joining and forming a large secondary arch and a short haemal spine. This short first haemal spine is apt to be overlooked and the second haemal spine counted as the first. Because of the large secondary arch, the very small haemal arches preceding it may be missed unless a careful examination is made. The preneural zygapophyses on the abdominal vertebrae extend upward into thin fanlike plates. The haemal and neural spines are moderately long and the parapophyses and haemapophyses long and heavy.

Individuals examined: 2 from Santa Catalina Island, 6 from Newport Beach and 2 from Lower California. Total vertebrae 26 (10); first haemal spine 10 (10); first haemal arch 6 (7), 7 (3). Dorsal IX, 12; anal III, 12.

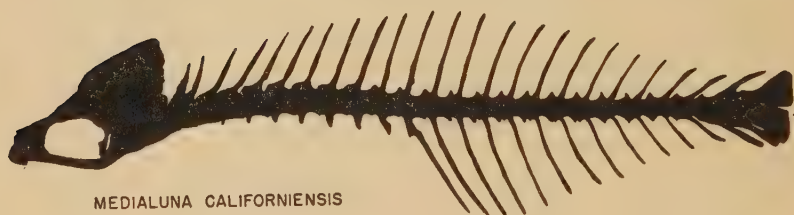
Oxyjulis californica (Günther). Señorita.

On the vertebra where the first haemal spine occurs, the haemapophyses join to form a small haemal arch and then extend outward and downward before again joining and forming a large secondary arch and a short haemal spine. This short first haemal spine is apt to be overlooked and the second haemal spine counted as the first. Because of the large secondary arch, the very small haemal arches preceding it may be missed unless a careful examination is made. The preneural zygapophyses on the abdominal vertebrae extend upward into thin fanlike plates. The haemal and neural spines are short and the parapophyses and haemapophyses are short and stubby.

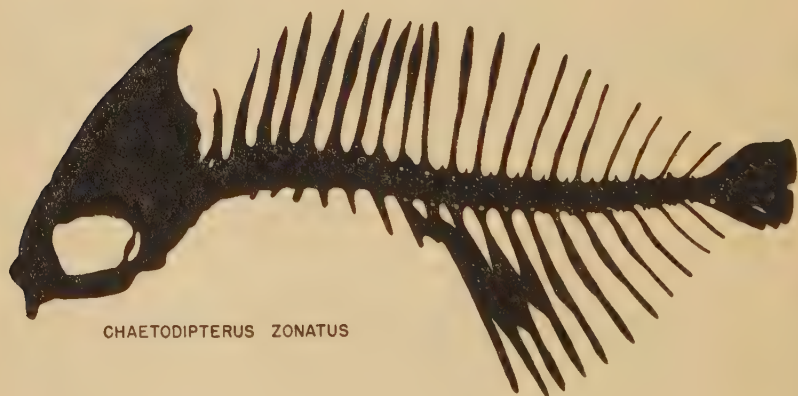
Individuals examined: 3 from the vicinity of Newport Beach and Laguna Beach, 1 from the vicinity of San Pedro, 7 from San Pedro fish markets, 1 from Santa Cruz Island and 2 from Monterey fish markets. Total vertebrae 26 (13), 27 (1); first haemal spine 11 (13), 12 (1); first haemal arch 5 (5), 6 (8), 8 (1). Dorsal IX to X, 13; anal III, 13.



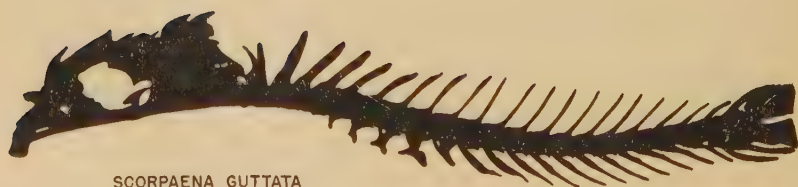
GIRELLA NIGRICANS



MEDIALUNA CALIFORNIENSIS



CHAETODIPTERUS ZONATUS



SCORPAENA GUTTATA

Girella nigricans (Ayres). Opaleye.

The supraoccipital crest is moderately high and pointed but short, not extending back to junction of the skull and the atlas. The haemal spines are long, the first quite close to the second.

Individuals examined: 2 from San Pedro fish markets, 15 from Laguna Beach and 8 from Portuguese Bend. Total vertebrae 27 (25); first haemal spine 12 (25); first haemal arch 9 (1), 10 (18), 11 (6). Dorsal XII to XIV, 12 to 15; anal III, 11 to 13.

Medialuna californiensis (Steindachner). Halfmoon.

The supraoccipital crest is high, extending back over the atlas. The haemal and neural spines are long.

Individuals examined: 1 from off Gaviota, 8 from San Pedro fish markets, 2 from San Clemente Island and 7 from Ensenada, Lower California. Total vertebrae 25 (18); first haemal spine 11 (18); first haemal arch 8 (3), 9 (10), 10 (5). Dorsal IX to X, 23 to 27; anal III, 18 to 21.

Chaetodipterus zonatus (Girard). Spadefish.

The posterior part of the skull is greatly enlarged and thickened and the supraoccipital crest is very high and pointed. The neural and haemal spines are long and heavy with the first four to five haemal spines greatly thickened antero-posteriorly, almost touching.

Individuals examined: 13 from Turtle Bay, Lower California. Total vertebrae 24 (13); first haemal spine 11 (13); first haemal arch 7 (8), 8 (5). Dorsal VIII-I, 18; anal II, 16.

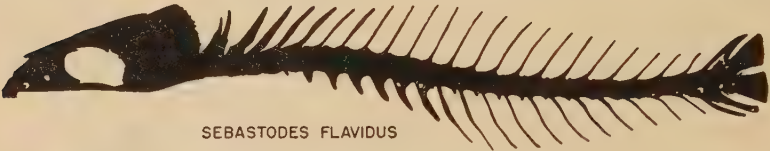
Scorpaena guttata Girard. Sculpin.

There are many spines on the skull. The haemaphyses have a forward projection parallel to the vertebral column ending in a sharp point. The first haemal spine is short and stubby.

Individuals examined: 1 from off Gaviota, 1 from Santa Catalina Island, 1 from Long Beach and 10 from San Pedro fish markets. Total vertebrae 24 (13); first haemal spine 10 (13); first haemal arch 7 (13). Dorsal XI-I, 10; anal III, 5.



SEBASTODES ROSACEUS



SEBASTODES FLAVIDUS



SEBASTODES PINNIGER



SEBASTODES CHLOROSTICTUS



SEBASTODES CARNATUS



SEBASTODES ATROVIRENS

Sebastodes sp.

This plate is included to illustrate the general resemblance of the various species of *Sebastodes*. In general the supraoccipital crest is moderately high and rounded. The haemal spines are of average length. The first haemal spine is shorter than the second. There are several spines around the orbit and on top of the skull, their number and location varying.

Individuals examined: 39 including the following species: *S. pinniger*, *S. flavidus*, *S. chlorostictus*, *S. semicinctus*, *S. atrovirens*, *S. miniatus*, *S. paucispinis*, *S. rosaceus*, *S. mystinus*, *S. carnatus*. Total vertebrae 26 (38) and 27 (1) (One specimen of *S. rosaceus* had 27 vertebrae.) ; first haemal spine 12 (39) ; first haemal arch 8 (22), 9 (14), 10 (3).



OPHIODON ELONGATUS



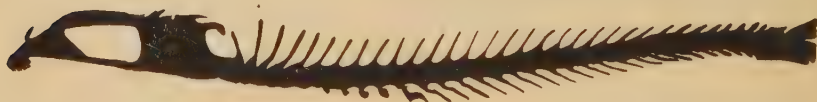
ZANIOLEPIS LATIPINNIS



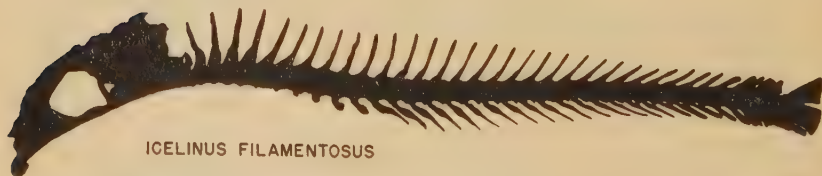
ZANIOLEPIS FRENATUS



SCORPAENICHTHYS MARMORATUS



CHITONOTUS PUGETENSIS



ICELINUS FILAMENTOSUS



ICELINUS TENUIS

Anaplopoma fimbria (Pallas). Sablefish (not illustrated).

Individuals examined: 1 from San Pedro fish markets, 12 from Eureka and 7 from Newport Beach. Total vertebrae 62 (4), 63 (9), 64 (6), 65 (1); first haemal spine 31 (6), 32 (13), 33 (1); first haemal arch 27 (3), 28 (10), 29 (4), 30 (3). Dorsal XVIII to XXI-16 to 19; anal 17 to 23.

Ophiodon elongatus Girard. Lingcod.

Individuals examined: 2 from Monterey fish markets and 10 from Eureka. Total vertebrae 56 (2), 57 (8), 58 (2); first haemal spine 24 (11), 25 (1); first haemal arch 22 (5), 23 (7). Dorsal XXV to XXVI-I to II, 19 to 21; anal 22 to 24.

Zaniolepis latipinnis Girard.

The second neural spine is longer than the third.

Individuals examined: 7 from Santa Cruz Island. Total vertebrae 41 (1), 42 (6); first haemal spine 15 (5), 16 (2); first haemal arch 11 (1), 12 (5), 13 (1). Dorsal XXI-I, 11; anal III, 17.

Zaniolepis frenatus Eigenmann.

The second neural spine is shorter than the third.

Individuals examined: 5 from Oceanside, 2 from San Francisco and 3 from Santa Cruz Island. Total vertebrae 41 (4), 42 (5), 43 (1); first haemal spine 15 (6), 16 (4); first haemal arch 12 (5), 13 (5). Dorsal XX-I, 12; anal III, 15 to 16.

Scorpaenichthys marmoratus Girard. Cabezone.

Individuals examined: 4 from the vicinity of San Pedro, 1 from Hueneme, 1 from Santa Catalina Island, 1 from La Jolla, 1 from Monterey, 1 from Bodega Head and 1 from off Humboldt County. Total vertebrae 36 (10); first haemal spine 16 (9), 17 (1); first haemal arch 12 (7), 13 (3). Dorsal XI to XII, 16 to 18; anal 12 to 13.

Hemilepidotus spinosus (Ayres). Sculpin (not illustrated).

Individuals examined: 2 from Monterey Bay. Total vertebrae 37 (2); first haemal spine 13 (2); first haemal arch 9 (2). Dorsal XI, 18 to 20; anal 14 to 16.

Chitonotus pugetensis (Steindachner). Sculpin.

Individuals examined: 12 from Santa Cruz Island, 2 from off Redondo Beach and 3 from the vicinity of Monterey. Total vertebrae 35 (8), 36 (9); first haemal spine 11 (2), 12 (15); first haemal arch 8 (2), 9 (12), 10 (3). Dorsal X to XI-14 to 17; anal 14 to 17.

Radulinus asprellus Gilbert. Sculpin (not illustrated).

The first haemal spine is very short consisting of barely more than the union of the haemapophyses inclosing the haemal arch. All neural and haemal spines are very short. All vertebrae from No. 33 to the urostyle have a keel on each side.

Individuals examined: 3 from between Monterey and San Francisco. Total vertebrae 38 (2), 39 (1); first haemal spine 13 (3); first haemal arch 11 (3). Dorsal IX to XI-21 to 23; anal 22 to 25.

Icelinus filamentosus Gilbert. Sculpin.

Individuals examined: 2 from Pt. Mugu. Total vertebrae 35 (1), 36 (1); first haemal spine 12 (2); first haemal arch 9 (1), 10 (1). Dorsal IX to XI-15 to 17; anal 13 to 15.

Icelinus tenuis Gilbert. Sculpin.

There are thin backward-projecting plates at the fusion of the haemapophyses on several vertebrae preceding the first haemal spine.

Individuals examined: 1 from the vicinity of Oceanside. Total vertebrae 38; first haemal spine 12; first haemal arch 8. Dorsal IX to XI-16 to 19; anal 13 to 17.

Icelinus quadriseriatus (Lockington). Sculpin (not illustrated).

The last three haemal and neural spines are enlarged into wide plates.

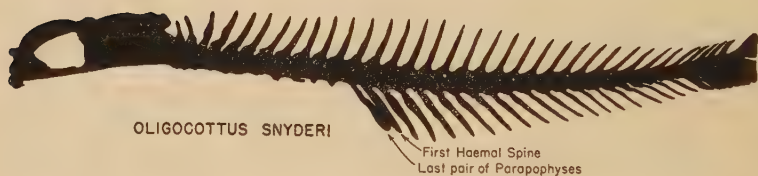
Individuals examined: 12 from Monterey Bay. Total vertebrae 33 (1), 34 (9), 35 (2); first haemal spine 10 (1), 11 (2), 12 (9); first haemal arch 8 (5), 9 (7). Dorsal VII to X-13 to 15; anal 11 to 13.



ICELINUS CAVIFRONS

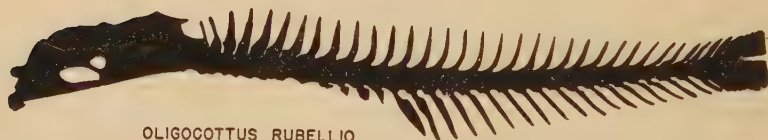


ARTEDIUS LATERALIS



OLIGOCOTTUS SNYDERI

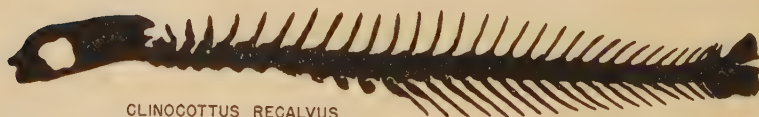
First Haemal Spine
Last pair of Parapophyses



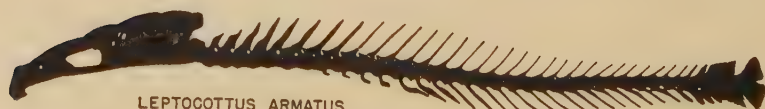
OLIGOCOTTUS RUBELLIO



CLINOCOTTUS ANALIS



CLINOCOTTUS RECALVUS



LEPTOCOTTUS ARMATUS

Icelinus cavifrons Gilbert. Sculpin.

Individuals examined: 3 from Santa Cruz Island and 3 from Monterey Bay. Total vertebrae 35 (5), 36 (1); first haemal spine 12 (6); first haemal arch 8 (3), 9 (3). Dorsal IX to X-13 to 15; anal 11 to 13.

Artedius notospilotus Girard. Sculpin (not illustrated).

Individuals examined: 1 from Monterey fish markets. Total vertebrae 34; first haemal spine 13; first haemal arch 10. Dorsal IX-14 to 16; anal 11 to 13.

Artedius lateralis (Girard). Sculpin.

Individuals examined: 10 from Monterey, 1 from Cayucos and 1 from north of Pismo Beach. Total vertebrae 32 (1), 33 (11); first haemal spine 12 (12); first haemal arch 9 (9), 10 (3). Dorsal VIII to X-16 to 17; anal 12 to 14.

Oligocottus maculosus Girard. Sculpin (not illustrated).

Individuals examined: 14 from the vicinity of Mendocino. Total vertebrae 33 (2), 34 (12); first haemal spine 12 (12), 13 (2); first haemal arch 9 (13), 10 (1). Dorsal VIII to IX-16 to 18; anal 12 to 14.

Oligocottus snyderi Greeley. Sculpin.

The haemal processes on the vertebra just preceding the first haemal spine are the same length as the first haemal spine and have their ends enlarged and thickened. They are apt to be confused with the first haemal spine.

Individuals examined: 9 from the vicinity of San Pedro and 23 from the vicinity of Monterey. Total vertebrae 34 (3), 35 (18), 36 (10), 37 (1); first haemal spine 11 (1), 12 (11), 13 (20); first haemal arch 8 (2), 9 (15), 10 (5) . . . 12 (3), 13 (7). (The break in the arch count is a sex characteristic, the females having the lower counts.) Dorsal VII to IX-17 to 20; anal 12 to 15.

Oligocottus rubellio (Greeley). Sculpin.

Individuals examined: 22 from various points on the coast ranging from San Diego to Monterey. Total vertebrae 32 (1), 33 (14), 34 (6), 35 (1); first haemal spine 12 (18), 13 (3), 14 (1); first haemal arch 8 (2), 9 (20). Dorsal VIII to IX-15 to 17; anal 12 to 14.

Clinocottus analis (Girard). Sculpin.

The atlas does not bear a neural spine, merely a pair of stubby processes which are not joined together.

Individuals examined: 37 from various localities ranging from Laguna Beach to Portuguese Bend and 13 from Monterey. Total vertebrae 31 (2), 32 (12), 33 (29), 34 (6), 35 (1); first haemal spine 11 (1), 12 (44), 13 (5); first haemal arch 9 (45), 10 (5). Dorsal VIII to X-15 to 18; anal 12 to 15.

Clinocottus recalvus (Greeley). Sculpin.

The last three haemapophyses preceding the first haemal spine end in a thin vertical plate projecting backward.

Individuals examined: 16 from various points ranging from Trinidad Head to San Pedro. Total vertebrae 32 (2), 33 (14); first haemal spine 12 (13), 13 (3); first haemal arch 9 (11), 10 (5). Dorsal VIII to IX-15 to 17; anal 10 to 13.

Clinocottus globiceps (Girard). Sculpin (not illustrated).

Individuals examined: 1 from the vicinity of the Smith River. Total vertebrae 33; first haemal spine 13; first haemal arch 11. Dorsal IX to X-13 to 17; anal 10 to 12.

Leptocottus armatus Girard. Staghorn Sculpin.

Individuals examined: 1 from San Pedro fish markets, 1 from Newport Bay and 9 from Mission Bay. Total vertebrae 35 (3), 36 (8); first haemal spine 12 (11); first haemal arch 8 (11). Dorsal VI to VIII-15 to 20; anal 15 to 20.

Odontopyxis trispinosa Lockington. (Not illustrated.)

The first haemal spine and the first haemal arch are on the same vertebra. A row of minute spines extends horizontally across the eye. These spines can be seen best when the specimen is stained.

Individuals examined: 3 from between Monterey and San Francisco. Total vertebrae 42 (3); first haemal spine 13 (3); first haemal arch 13 (3). Dorsal V to VI-6 to 7; anal 5 to 6.

Gasterosteus aculeatus Linnaeus. Threespine Stickleback (not illustrated).

There is a large hole at the base of each haemal spine. This hole is so large that it spreads the base of the spine over practically the complete length of the centrum.

Individuals examined: 7 from the vicinity of the San Francisco lightship. Total vertebrae 31 (2), 32 (5); first haemal spine 16 (7); first haemal arch 12 (2), 13 (3), 14 (2). Dorsal II-I, 12 to 13; anal I, 9 to 10.

Aulorhynchus flavidus Gill. (Not illustrated.)

The first haemal spine and the first haemal arch are on the same vertebra. The last pair of parapophyses are greatly broadened fore and aft and curved back against the haemopophyses of the first haemal spine.

Individuals examined: 3 from the vicinity of San Pedro and 7 from Pt. Arguello. Total vertebrae 54 (3), 55 (5), 56 (2); first haemal spine 26 (6), 27 (4); first haemal arch 26 (6), 27 (4). Dorsal XXIV to XXVI-9 to 11; anal I, 9 to 10.

Syngnathus californiensis Storer. Kelp Pipefish (not illustrated).

The first two vertebrae are completely covered over laterally by bony modifications of the parapophyses and dorsally by the neural processes. The parapophyses on the second vertebra extend outward, downward and then inward, the ends almost crossing each other. All remaining vertebrae carry bony processes projecting horizontally from the middle of the centrums. The neural spines on each vertebra form thin plates which are most conspicuous in the midregion of the vertebral column and diminish in height to practically nothing on the last vertebra. All haemal spines are exceedingly short and weak.

Individuals examined: 5 from vicinity of San Pedro. Total vertebrae 65 (1), 72 (3), 74 (1); first haemal spine 23 (1), 24 (1), 25 (3); first haemal arch 23 (1), 24 (1), 25 (3). Dorsal 39 to 46; anal 5.



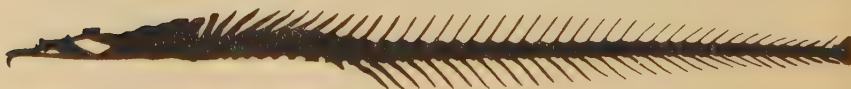
CORYPHOPTERUS NICHOLSII



GILLICHTHYS MIRABILIS



CLEVELANDIA IOS



PORICHTHYS NOTATUS

Coryphopterus nicholsii (Bean). Goby.

The first haemal arch is normal. The following vertebra has a small arch and in addition a greatly enlarged arch, the haemapophyses of which are bent back toward the first haemal spine. (See fig. 5.) All spines are short and weak.

Individuals examined: 1 from the vicinity of Oceanside and 3 from the vicinity of San Pedro. Total vertebrae 26 (4); first haemal spine 12 (4); first haemal arch 10 (4). Dorsal V-II, 9 to 14; anal I, 11.

Gillichthys mirabilis Cooper. Mudsucker.

The maxillary is broadened behind and extends back to the base of the pectoral fin in the adult.

Individuals examined: 17 from Seal Beach and Huntington Beach. Total vertebrae 31 (1), 32 (15), 33 (1); first haemal spine 15 (15), 16 (2); first haemal arch 13 (1), 14 (15), 16 (1). Dorsal VI-I, 12 to 13; anal I, 11 to 13.

Quietula y-cauda (Jenkins & Evermann). Goby (not illustrated).

The parapophyses on the third vertebra project sideways for a distance about the length of one centrum and then gradually shorten on the next four vertebrae, reaching a length of about one half a centrum.

Individuals examined: 18 from Newport Bay. Total vertebrae 33 (16), 34 (2); first haemal spine 14 (1), 15 (17); first haemal arch 12 (1), 13 (15), 14 (2). Dorsal IV to V-I, 13 to 15; anal I, 12 to 14.

Ilypnus gilberti (Eigenmann & Eigenmann). Goby (not illustrated).

The parapophyses on the third vertebra project sideways for a distance about the length of one centrum and then gradually shorten on the next four vertebrae, reaching a length of about one half a centrum.

Individuals examined: 21 from the vicinity of San Diego. Total vertebrae 32 (1), 33 (18), 34 (2); first haemal spine 14 (2), 15 (19); first haemal arch 12 (1), 13 (9), 14 (11). Dorsal V-14 to 17; anal 12 to 16.

Clevelandia ios (Jordan & Gilbert). Goby.

The first haemal spine and the first haemal arch are on the same vertebra in the older fish. The first haemal arch is from 1 to 2 vertebrae in advance of the first haemal spine in the younger fish.

Individuals examined: 10 from Newport Bay. Total vertebrae 36 (10); first haemal spine 16 (10); first haemal arch 14 (4), 15 (2), 16 (4). Dorsal IV to V-O to I, 14 to 15; anal I, 14 to 15.

Typhlogobius californiensis Steindachner. Blind Goby (not illustrated).

Individuals examined: 1 from Santa Catalina Island and 9 from Portuguese Bend. Total vertebrae 31 (9), 32 (1); first haemal spine 17 (2), 18 (6), 19 (2); first haemal arch 17 (2), 18 (8). Dorsal III-12; anal I, 8 to 10.

Porichthys notatus Girard. Midshipman.

The skull is very flat and depressed. The haemal and neural spines are short, the anterior ones thickened. The upper lobe of the urostyle is in two pieces with a joint between them similar to all other joints between the centrums. (See fig. 21.) The vomer has two curved fanglike teeth.

Individuals examined: 3 from north of Pt. Conception, 4 from Santa Rosa Island, 2 from Santa Catalina Island and 1 from the vicinity of San Pedro. Total vertebrae 42 (1), 43 (3), 44 (5), 45 (1); first haemal spine 11 (3), 12 (6), 13 (1); first haemal arch 8 (1), 9 (2), 10 (7). Dorsal II-33 to 37; anal 29 to 34.



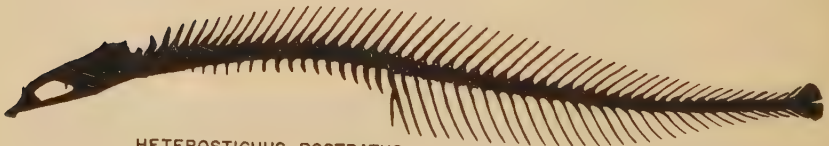
PARACLINUS INTEGRIPINNIS



GIBBONSIA ELEGANS



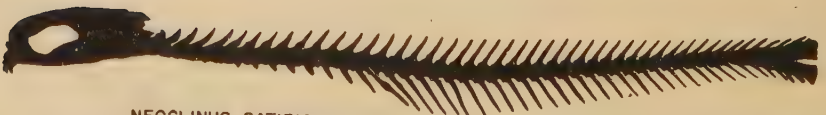
GIBBONSIA METZI



HETEROSTICHUS ROSTRATUS



NEOCLINUS BLANCHARDI



NEOCLINUS SATIRICUS

Porichthys myriaster Hubbs & Schultz. Midshipman (not illustrated).

The skull is very flat and depressed. The haemal and neural spines are short, the anterior ones thickened. The upper lobe of the urostyle is in two pieces with a joint between them similar to all other joints between the centrums. (See fig. 21.) The vomer has two curved fanglike teeth.

Individuals examined: 4 from San Pedro fish markets, 4 from Santa Cruz Island, 1 from Anacapa Island, 5 from the vicinity of Santa Barbara and 1 from the vicinity of San Pedro. Total vertebrae 46 (1), 47 (6), 48 (6), 49 (2); first haemal spine 12 (7), 13 (8); first haemal arch 10 (11), 11 (4). Dorsal II-36 to 40; anal 33 to 39.

Rimicola eigenmanni (Gilbert). Clingfish (not illustrated).

There are extremely long parapophyses on the abdominal vertebrae.

Individuals examined: 10 from the vicinity of San Diego. Total vertebrae 33 (5), 34 (4), 35 (1); first haemal spine 16 (3), 17 (7); first haemal arch 15 (7), 16 (3). Dorsal 5 to 6; anal 5 to 7.

Infratridens rhessodon (Smith). Clingfish (not illustrated).

The first haemal spine and the first haemal arch are on the same vertebra. The haemal and neural spines are short and stubby, especially the neural spines. The first rays of the dorsal and anal fins are so small they are apt to be overlooked without dissection or clearing and staining.

Individuals examined: 7 from Portuguese Bend, 4 from near Pt. Fermin, 2 from Laguna Beach and 7 from San Diego. Total vertebrae 28 (3), 29 (16), 30 (1); first haemal spine 14 (20); first haemal arch 14 (20). Dorsal 11 to 13; anal 9 to 11.

Paraclinus integripinnis (Smith).

There is no supraoccipital crest. The epiotics have low, thin crests extending forward in a "V" to meet on top of the skull behind the orbit. The frontal drops vertically to the vomer.

Individuals examined: 11 from San Diego, 2 from Laguna Beach and 8 from near Pt. Fermin. Total vertebrae 37 (9), 38 (12); first haemal spine 11 (2), 12 (19); first haemal arch 9 (2), 10 (3), 11 (16). Dorsal XXXI to XXXII; anal II, 19 to 20.

Gibbonsia elegans (Cooper). Kelpfish.

Individuals examined: 2 from Newport Beach, 24 from Laguna Beach, 24 from near Pt. Fermin, and 4 from Portuguese Bend. Total vertebrae 48 (40), 49 (14); first haemal spine 17 (1), 18 (50), 19 (3); first haemal arch 16 (1), 17 (35), 18 (17), 19 (1). Dorsal XXXII to XXXIV, 5 to 8; anal II, 21 to 25.

Gibbonsia montereyensis Hubbs. Kelpfish (not illustrated).

Individuals examined: 6 from Monterey. Total vertebrae 50 (5), 51 (1); first haemal spine 17 (6); first haemal arch 15 (1), 16 (3), 17 (2). Dorsal XXXIV to XXXVI, 5 to 8; anal II, 23 to 28.

Gibbonsia metzi Hubbs. Kelpfish.

The first haemal spine and the first haemal arch are nearly always on the same vertebra.

Individuals examined: 3 from Laguna Beach, 5 from near Pt. Fermin and 15 from Monterey. Total vertebrae 51 (14), 52 (9); first haemal spine 19 (17), 20 (6); first haemal arch 18 (1), 19 (20), 20 (2). Dorsal XXXIV to XXXVII, 7 to 9; anal II, 24 to 27.

Heterostichus rostratus Girard. Kelpfish.

The first haemal spine was bifurcate on 4 of the 13 specimens examined. The first haemal arch and the first haemal spine are on the same vertebra.

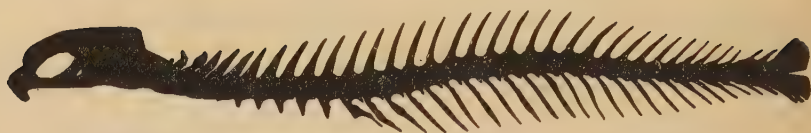
Individuals examined: 10 from Newport Beach, 2 from Laguna Beach and 1 from near Pt. Fermin. Total vertebrae 56 (1), 57 (11), 58 (1); first haemal spine 23 (13); first haemal arch 23 (13). Dorsal XXXIII to XXXVII, 12 to 13; anal II, 33 to 34.

Neoclinus blanchardi Girard.

Individuals examined: 1 from Santa Cruz Island. Total vertebrae 48; first haemal spine 15; first haemal arch 12. Dorsal XXIV, 17; anal II, 30.

Neoclinus satiricus Girard.

Individuals examined: 3 from San Pedro and 1 from Morro Bay. Total vertebrae 46 (1), 47 (1), 48 (1), 49 (1); first haemal spine 15 (4); first haemal arch 12 (2), 13 (2). Dorsal XXIV to XXVI, 17; anal 30 to 32.



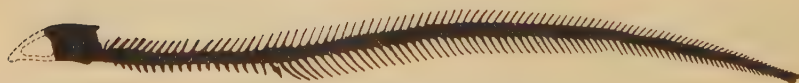
HYPSOBLENNIUS GILBERTI



ANARRHICHTHYS OCELLATUS



SEBIDIICHTHYS VIOLACEUS



LYCODOPSIS PACIFICA

Hypsoblennius gilberti (Jordan). Blenny.

Individuals examined: 2 from Laguna Beach, 2 from San Pedro and 6 from La Jolla. Total vertebrae 37 (9), 38 (1); first haemal spine 11 (9), 12 (1); first haemal arch 8 (1), 9 (6), 10 (2), 11 (1). Dorsal XII, 18; anal II, 19.

Anarrhichthys ocellatus Ayres. Wolf-eel.

The first haemal spine and the first haemal arch are on the same vertebra. The bones of the skull are large and massive. There are blunt molars on the vomer and on the parasphenoid.

Individuals examined: 1 from Monterey fish markets. Total vertebrae 242; first haemal spine 39; first haemal arch 39. The fin counts on this one specimen were dorsal CCL; anal 233.

Cebidichthys violaceus (Girard). Blenny-eel.

The first haemal spine and the first haemal arch are on the same vertebra. The first haemal spine is much shorter than the second.

Individuals examined: 1 from Monterey, 2 from vicinity of San Pedro and 1 from Lower California. Total vertebrae 69 (1), 70 (1), 71 (1), 74 (1); first haemal spine 22 (1), 23 (1), 25 (2); first haemal arch 22 (1), 23 (1) 25 (2). Dorsal XXIII, 41 to 42; anal I, 41 to 51.

Epigeeichthys atro-purpureus (Kittlitz). Blenny-eel (not illustrated).

Individuals examined: 15 from Monterey and 1 from Lower California. Total vertebrae 73 (1), 74 (4), 75 (4), 76 (5), 77 (2); first haemal spine 23 (4), 24 (12); first haemal arch 23 (5), 24 (11). Dorsal LXIII to LXXI; anal 50 to 52.

Xerperes fucorum (Jordan & Gilbert). (Not illustrated.)

The first haemal spine and the first haemal arch are on the same vertebra. The first haemal spine is extremely short. The succeeding haemal spines gradually increase in length, reach a maximum and then gradually shorten toward the urostyle.

Individuals examined: 2 from Monterey, 5 from near Pt. Fermin and 1 from Portuguese Bend. Total vertebrae 84 (1), 88 (2), 89 (2), 90 (3); first haemal spine 5 (8); first haemal arch 5 (8). Dorsal LXXXII to LXXXVI; anal I, 29 to 31.

Ulvicola sanctae-rosae Gilbert & Starks. (Not illustrated).

Individuals examined: 10 from Santa Cruz Island. Total vertebrae 105 (4), 106 (5), 107 (1); first haemal spine 52 (3), 53 (4), 54 (3); first haemal arch 4 (4), 5 (6). Dorsal XCVII; anal I, 40.

Lycodopsis pacifica (Collett). Eelpout.

The first haemal spine and the first haemal arch are on the same vertebra. All haemal and neural spines are comparatively short. The parapophyses on the vertebra preceding the first haemal spine are enlarged and extended backwards.

Individuals examined: 8 from between Eureka and Crescent City. Total vertebrae 104 (3), 105 (2), 106 (2), and 1 in which the tail vertebrae were lost in cleaning; first haemal spine 22 (4), 23 (4); first haemal arch 22 (4), 23 (4). Dorsal 100; anal 85.



OTOPHIDIUM SCRIPPSI



OTOPHIDIUM TAYLORI



VERRUNCULUS POLYLEPIS

Melanostigma pammelas Gilbert. Eelpout (not illustrated).

Individuals examined: 2 from vicinity of Monterey. Total vertebrae 88 (1), 89 (1); first haemal spine 20 (1), 21 (1); first haemal arch 20 (1), 21 (1). Dorsal 73 to 77; anal 64 to 65.

Otophidium scrippsi Hubbs. Cusk-eel.

The first haemal arch and the first haemal spine are on the same vertebra. The atlas has 2 pairs of large parapophyses. The upper pair extend outward and backward while the lower pair extend outward and then curl downward. The second to fifth vertebrae have no parapophyses. From the sixth vertebra on there are long parapophyses partially inclosing the adominal cavity. The 4th and 5th vertebrae each have a heavy bony process projecting ventrally from the midline of the centrum which join to form a bony structure and to which is rather tightly attached a singular hemispherical structure (not shown in the illustration) almost inclosing the anterior end of the abdominal cavity, leaving barely enough room for the gullet to pass underneath it.

Individuals examined: 13 from the vicinity of San Pedro. Total vertebrae 67 (4), 68 (4), 69 (5); first haemal spine 16 (3), 17 (8), 18 (2); first haemal arch 16 (3), 17 (8), 18 (2). Dorsal 136 to 153; anal 113 to 119.

Otophidium taylori (Girard). Cusk-eel.

The first haemal arch and first haemal spine are on the same vertebra. The atlas has two pairs of parapophyses similar to but smaller than in *O. scrippsi*. The same hemispherical structure at the anterior end of the abdominal cavity is present though it is smaller, lighter and more loosely attached to the 4th and 5th vertebrae than with *O. scrippsi*.

Individuals examined: 1 from the vicinity of San Pedro, 1 from Santa Monica Bay, 1 from Santa Cruz Island, 7 from the vicinity of Santa Barbara and Gaviota, and 1 from vicinity of San Francisco lightship. Total vertebrae 87 (2), 88 (8), 89 (1); first haemal spine 19 (9), 20 (2); first haemal arch 19 (9), 20 (2). Dorsal 203 to 214; anal 156 to 170.

Verrunculus polylepis (Steindachner). Triggerfish.

The first haemal arch and first haemal spine are on the same vertebra. The skeletal bones are porous and light in weight in spite of their massive appearance. The anterior bones of the skull are enlarged and produced into a long snout. The first, second and third haemal spines are widened laterally and joined together to form a bony plate over the posterior part of the abdominal cavity.

Individuals examined: 9 from the Gulf of California and 1 found in a shipment of Mexican fish at the San Pedro fresh fish markets. Total vertebrae 18 (10); first haemal spine 6 (10); first haemal arch 6 (10). Dorsal III, 27; anal 25 to 26.

Mola mola (Linnaeus). Ocean Sunfish (not illustrated).

The skeleton is largely cartilaginous and shrivels and curls when dried. The first three neural spines are joined together into a very low double plate scarcely rising above the centrums. The urostyle is produced into a rodlike structure.

Individuals examined: 2 from load of sardines at Terminal Island cannery. Total vertebrae 18 (2); first haemal spine 10 (2); first haemal arch 10 (2). Dorsal 17; anal 18.

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APPENDIX

CLEARING AND STAINING TECHNIQUE MODIFIED FROM HOLLISTER

If the specimen is fresh, it must be hardened for a day or two in formaldehyde. Fresh specimens went to pieces before they cleared when held in 4 percent potassium hydroxide. Alcohol specimens must also be hardened in formaldehyde. This hardening is in contradiction to Hollister, who found that best results were obtained from fresh specimens. The explanation is probably that Hollister was interested in quality rather than quantity and used much weaker solutions. Before placing in formaldehyde the viscera should be removed, since partially digested remains in the alimentary tract along with ingested bits of rock and shell will obscure the vertebral column in the finished specimen.

From formaldehyde the specimen is put into a solution of 4 percent potassium hydroxide prepared from white sticks U.S.P. and distilled water. The fish is allowed to remain in the potassium hydroxide solution for a time varying from a few hours up to several weeks, depending upon the size and toughness of the specimen. When the vertebrae can be dimly seen for the last half to two-thirds of the length of the fish it is ready for staining.

The staining solution is prepared from one part of a saturated solution of alizarin in glacial acetic acid, two parts of pure glycerine, and twelve parts of a 1 percent solution of chloral hydrate crystals dissolved in distilled water. This staining solution can be made up in quantity and kept in a glass bottle for use as needed. A flocculent precipitate will appear and the solution should be shaken up just before using.

For staining, the old potassium hydroxide solution is drawn off and fresh solution is added. The staining solution is then added slowly until a deep violet-purple color is obtained. (It will take approximately one-fifth to one-tenth as much staining solution as there is potassium hydroxide solution to obtain this color.)

The specimen is left in the stain for one to two days (a few hours will suffice for larval and postlarval forms) and then the stain is drawn off and fresh potassium hydroxide solution is added. If the specimen has scales which will obscure vision, they may now be removed. They will be deeply stained and therefore highly visible, and they will have become so loose that they may be removed merely by rubbing a dissecting needle back and forth over the surface of the fish.

When most of the stain has been leached out of the flesh (destained) the specimen is ready to be run up to pure glycerine in nine steps. Prepare nine jars and label the caps from 1 to 9. Fill these jars with glycerine and 4 percent potassium hydroxide solution in the following proportions of glycerine: Jar "1" 20 percent, jar "2" 40 percent, jar "3" 55 percent, jar "4" 70 percent, jar "5" 80 percent, jar "6" 90 percent, jar "7" 95 percent, jars "8" and "9" both 100 percent glycerine.

Draw off the potassium hydroxide and pour in some glycerine solution from jar "1". Move the specimen up through each glycerine step to the final 100 percent in jar "9", allowing it to remain in each step from 24 to 48 hours. Final preservation is made in new 100 percent glycerine to which is added a crystal of thymol to prevent mold. As the solutions are used they become discolored with stain and weaker in strength. The specific gravity of jar "1" should not be allowed to drop below 1.125. If at any time the solution in jar "8" begins to show traces of discoloration or if the specific gravity of the first jar falls below 1.125 discard the contents of the first jar and move all the jar caps up one step. Thus jar "2" becomes "1", jar "3" becomes "2", etc. Wash and dry jar "1" and fill with 100 percent glycerine and start it in at the head of the line with the "9" cap on it. In the final preservation of the specimen, glass or rubber stoppers should be used since cork will discolor the glycerine which in turn will discolor the specimen.

The fish should be watched closely throughout the clearing, staining, and destaining periods for signs of loosening fin rays or lower jaw parts, and if such signs are seen the process should be greatly accelerated to get the specimen into the glycerine as soon as possible. Often a specimen about to go to pieces may be saved by eliminating the destaining step entirely and allowing the stain to soak out in the first one or two glycerine steps. This has the disadvantage of discoloring the glycerine solutions, but will often save the specimen.

Note that at no time is the specimen "placed in a solution". The old solution is always drawn off by means of a small pipette and the new solution is added the same way. Every precaution is taken to avoid moving or disturbing the fish any more than can be helped.

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